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The Conklingville Reservoir Project and the Permanent Gaging Station on the Sacandaga River Near Hadley, N. Y.*

By C. C. COVERT,† Assoc. M. Am. Soc. C. E., and D. R. COOPER,‡ Assoc. M. Am. Soc. C. E.

The U. S. Geological Survey, in cooperation with the New York State Water Supply Commission, has recently completed the installation and equipment of a permanent stream-gaging station on the Sacandaga River near Hadley, N. Y. Some of the features of the station constitute comparatively new departures in stream-gaging methods, and it is therefore thought that an account of the installation and equipment of the station, the methods employed, and the cost of the equipment and work, will be of interest to engineers and others having to do with stream-gaging methods and stream-flow records. At the same time some information will be given regarding the cooperation of the United States and the State of New York in stream-gaging work, and also a brief description of the Conklingville dam and storage-reservoir project.

STREAM-GAGING BY GEOLOGICAL SURVEY.—Since 1888 the U. S. Geological Survey has been accumulating data regarding the discharge of the most important streams throughout the United States. This work was started primarily in connection with irrigation studies in the arid west. The funds were originally obtained from the general appropriations of the Geological Survey. In 1894 the popular demand for stream-flow data for use in the design of power developments in the east became so great that Congress made specific appropriations for the work and the Water Resources Branch was organized. District offices were established and investigations were carried on in cooperation with various states. On account of the limited funds available, it was considered advisable to establish stations only on streams of the greatest importance and the data so gathered have been used, not only for the streams on which they were obtained, but as basic data for estimating the flow of similar streams. The investigations have gradually been extended to include a number of the smaller streams.

The development of electrical transmission, the increased demand for power for manufacturing and domestic purposes, the increased population of the country and the resultant increase in valuation of property subject to flood damages from our larger streams, have given a more important aspect to the present and future problems of river hydraulics. In recent times the problem is not simply the development of the individual plant that it may approximately utilize the ordinary flow of the stream, but the possibility for the development of a greater number of plants of higher efficiency and the practically complete control of the total discharge. Under these conditions, water as a natural resource is destined to have even a greater influence in the future up-building of this country than it has had in the past. The water-supply, like the winds, is continually renewed, only its rate of availability being limited, and even that is subject to control through scientific investigation and proper management.

INVESTIGATIONS BY NEW YORK STATE WATER SUPPLY COMMISSION.—New York State, as well as several other eastern states, has created by law a State Water Supply Commission, one of whose duties is to investigate the possibilities for regulation of the flow of streams and development of water-powers within the state and to recommend plans for a systematic and economical development in order that not only the various existing water-powers may be improved, but that new powers may be developed, destructive floods diminished and this great natural resource be utilized to create a revenue to the state. The study of the problem along these lines involves investigations of the possibilities for immense reservoirs. In order that they may be economically designed, it is necessary to secure great accuracy in the accumulation of the data relating to the annual run-off of the streams under consideration.

In 1907 the Water Supply Commission started active cooperative work with the Water Resources Branch of the Geological Survey and established a number of gaging stations on several of the streams which were proposed to be studied, the data to be used in conjunction with other records obtained by the Survey since the work was started in New York State in 1898.

CONKLINGVILLE PROJECT.—One of the most promising opportunities developed by the Water Supply Commission's investigations is what is known as the Conklingville project on the Sacandaga River. A dam constructed across

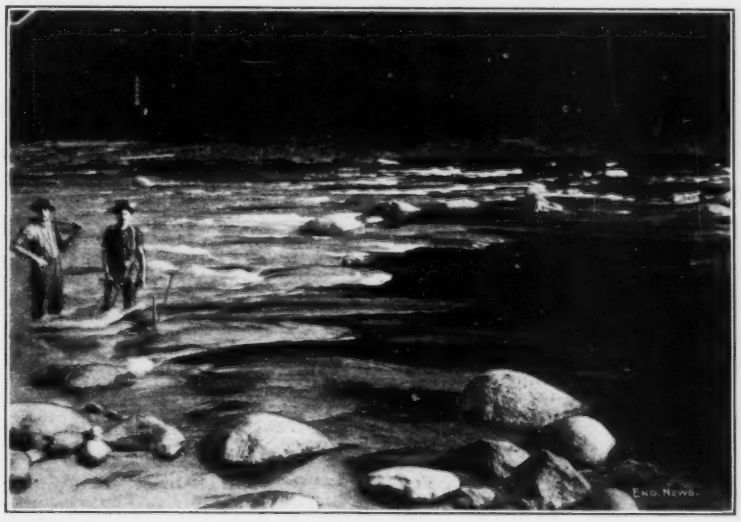

Fig. 1. Before Removing Boulders.

Fig. 2. After Removing Boulders.

VIEWS OF SACANDAGA RIVER AT SITE OF GAGING STATION.

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the narrow valley in the vicinity of Conklingville, about seven miles by river from the mouth, would impound from 30,000,000,000 to 40,000,000,000 cu. ft. of water, as may be found desirable when more extensive stream-flow records are available. In connection with this dam a fall of about 200 ft. would make possible a power development of from 30,000 to 35,000 continuous horsepower by means of a pressure tunnel about two miles long, which would include the fall of the main portion of the rapids in the river below the dam site in addition to the head created by the construction of the dam. The release of the stored water would also result in a high degree of regulation of the flow in the Hudson River below this point, the total fall from the tail-race of the proposed power-house to tidewater at Troy being about 555 ft., of which about 380 ft. of working head is developed at the present time. The proposed storage reservior is estimated to cost about $4,500,000.

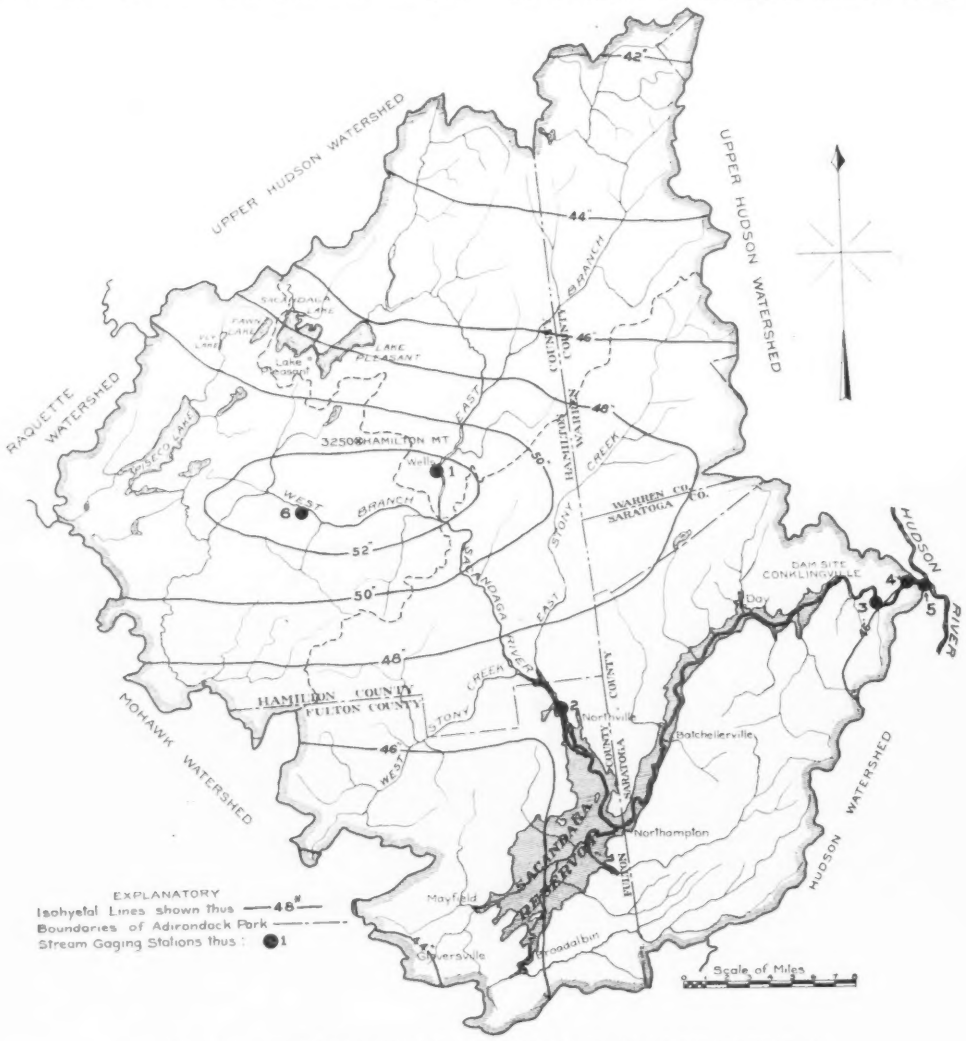

FIG. 3. GENERAL MAP OF SACANDAGA RIVER DRAINAGE AREA.

SACANDAGA WATERSHED.—The Sacandaga River is the principal tributary to the upper Hudson River, having a catchment area of 1,064 square miles and emptying into the Hudson River at Hadley, N. Y., about 50 miles north of Albany. It drains the southeastern portion of the Adirondack Mountain region and 60 or 70% of the tributary drainage area is wooded. The surfaces of lakes and ponds comprise approximately 2% of the area, and in addition to numerous swamps of less extent, there are on the watershed two large swamps having areas of several thousand acres, one of which occupies the bottom of an ancient lake bed in what is known as "The Big Vlaie," south of Northville, N. Y. The surface elevations range from 3,250 ft. above sea level at the crest of the watershed on Hamilton Mt. to 540 ft. at the mouth of the river just below Hadley.

RAINFALL.—The combined snow and rainfall varies from a yearly maximum, minimum and average of 59.7, 39.9 and 53.6 ins., respectively, in the region of greatest precipitation, which is on the West Branch in the upper portion of the catchment area, to a yearly maximum, minimum and average of 58.0, 37.5 and 45.8 ins., respectively, in the region of least precipitation, which is near the mouth of the river. An exhaustive study of all available rainfall records indicates what may properly be termed the annual mean effective precipitation for the entire catchment area to be about 48 ins., as compared with 38 ins. for the entire State of New York.

TEMPORARY GAGING STATIONS.—In 1907 three gaging stations were established on the Sacandaga, one on the East Branch at Wells, one at Northville below the mouth of the West Branch, and one near the mouth of the river at what is known as the Upper Hadley Bridge. (See Fig. 3.) In 1909 an additional station was established near the mouth of the river at the Lower Hadley Bridge, and in 1910 one on the West Branch at Whitehouse. A standard chain gage was installed at each of these points and observations have been made twice each day by local observers. On account of local conditions it has been impossible to obtain an accurate continuous estimate of the discharge at any one of these stations. The least reliable records are those obtained during the high-water stages of early spring, resultant from the run-off of accumulated snowfall. At this time log and ice jams form at various points and they have invariably caused back-water conditions at the stations during the most critical period. It is believed that the two observations, one in the morning and one at night, do not truly indicate the fluctuations of flow during the entire 24-hour period, and that they may easily be misleading in regard to the absolute maximum discharge and the period during which this maximum maintains. In order to overcome these difficulties a careful study of the situation was made, covering a period of two years, with a view to locating a place which would be free from back-water conditions during the floods and which would offer more favorable conditions for gaging the flow at all stages. In the study of this problem due consideration was given to the future value of the station in determining the volume of water to be released from the proposed reservoir and in obtaining data for its design and construction.

PERMANENT GAGING STATION.—It is desirable for a good gaging station to have a straight course and a permanent bed and one which is comparatively regular and smooth. About one-half mile above the mouth of the stream and six miles by river below the proposed dam at Conklingville, there is a fairly straight course nearly 1,000 ft. in length. The river bed throughout this section is typical of streams in the Adirondack Mts., being full of large boulders and coarse gravel. The slope is rather uniform but quite rapid, being about 30 ft. to the mile. It was noticed that during the spring break-up very few logs lodged in this section of the river, never enough to cause back-water conditions. The current is swift enough so that during the winter practically no trouble is expected from ice. In general the conditions seem to afford the most favorable site for studying the continuous flow of the river. Continuous, as well as accurate, records of daily fluctuations are essential to a thorough study of the run-off of any drainage basin, these records to be supplemented by discharge measurements covering a range of stage the limits of which are the minimum and maximum gage heights.

CLEARING CHANNEL.—At the location selected the natural conditions afforded a straight course but it was considered advisable to remove the boulders and smooth off the cross section in order to avoid cross currents and to facilitate meter observations. This was accomplished by the use of dynamite. The boulders were drilled and loaded by men wading in the river. Over 100 boulders were removed, ranging in size from a one-man stone to boulders 6 and 8 ft. in diameter. These were shattered and the fragments were spread about in the channel. The conditions of the stream bed before operations were begun is shown by Fig. 1. Fig. 2 shows the improved channel. Subsequent to the date of this photograph (Fig. 2) the small obstructions, which can be noted in the center of the channel, were removed, but photographs taken since that time did not develop satisfactorily. The pictures were taken at practically the same stage, the water was only about .15-ft. lower for Fig. 2 than for Fig. 1.

The low-water width of the channel at this point is 200 ft. The bank on the right side is steep and rises about 50 ft. above the river bed; the left bank is comparatively low, being only about 2 ft. above high-water mark; both banks are more or less wooded and have a rough boulder exposure below high-water line.

CABLEWAY EQUIPMENT.—In order to make measurements at all stages it was necessary to provide a suitable support for the hydrographer. This was accomplished by stretching across the stream a ⅝-in. galvanized-wire rope, anchored on the right bank to a large tree whose base was at practically the elevation required for the cable. On the left bank local conditions made it necessary to provide an artificial support. Along this side of the river there passes a highway leading from Hadley to Conklingville and points beyond. The distance between the edge of this highway and the top of the river bank is about 10 ft. The bank has an abrupt slope to low water. In order to afford sufficient clearance over the center of the channel during high water it was necessary to elevate this end of the cable about 15 ft. An A-shaped frame (see Fig. 4) was constructed out of 2 × 6-in. spruce, spiked two pieces together and spliced, making them 15 ft. in length. These were spaced center to center, 2 ft. at the top and 7 ft. at the bottom. Across the top two pieces of 2 × 6-in. plank were bolted supporting a 10-in. sheave through which the cable passes to a 1-in. gal-

vanized-iron turnbuckle, having a 3-ft. takeup; this in turn is fastened to an anchor bolt in a concrete "deadman" 4 × 3 × 3 ft., placed just below the surface of the ground and approximately 13 ft. distant from the A-frame, which supports the cable. The A-frame has a bottom sill 6 × 6 ins. × 8 ft. which rests on a concrete foundation to which it is fastened by three 1-in. bolts. It was necessary to place this foundation below the top of the bank on account of the nearness of the highway. The A-frame is prevented from tipping forward by a guy wire leading from the top to the eye-bolt in the concrete "deadman." A standard type car, designed by Mr. J. C. Stevens, formerly district engineer, U. S. Geological Survey, in charge of the Portland office, is used. (See Eng. News, May 6, 1909, p. 483.) This is supported upon the cable by 10-in. sheaves having roller bearings (see Fig. 5). By means of this equipment it is a comparatively easy matter to measure the flow at any and all stages.

CURRENT-METER MEASUREMENTS.—For the benefit of readers who may not be familiar with current-meter measurements it seems proper briefly to describe the methods used. The bridge or cable from which the measurements are made is marked off into sections varying from 2 to 20 ft., depending upon the character of the stream. The water surface is referred to a gage or permanent reference point and recorded. Soundings are then taken at each of the intervals. By numerous experiments it has been proved that the mean velocity in the vertical lies at a point approximately .6 of the total depth from the top, or that the average of two observations at .2 and .8 of the depth from the top will give the mean velocity. Measurement of the velocity at .6 of the depth is called the "single-point" method, at .2 and .8 of the depth the "two-point" method. For depths greater than 1 ft. the latter is more accurate and has been adopted by the Survey.

In taking the observations the center of the revolving cups is placed for each interval at the depth or depths above indicated and the number of revolutions is determined for a period ranging from 40 to 70 seconds by use of a stop watch and an electrical apparatus which records the revolutions. The meter having been previously rated by passing it through still water at various speeds, covering the range of velocities for which it is to be used, and a rating table having been developed, the velocity in the vertical under each division point is computed. Given the total width of the stream, the depth in feet and the mean velocity in each vertical, the discharge of the stream is readily computed. In making measurements by wading, the cable and weight are dispensed with and the meter is attached directly to a steel rod, the method being otherwise the same.

GAGE-RECORD EQUIPMENT. — Frequent gage heights are of as much importance in obtaining accurate continuous records as the current-meter discharge measurements. As stated before, it was considered advisable in this instance to provide for a continuous record. Therefore, provision was made for the installation of a recording gage with a suitable concrete well and shelter. The soil along the banks of the river being of boulder hardpan, the work of excavation was extremely difficult. It was necessary at times to resort to blasting in order to remove boulders which were continually encountered during the excavation. The well was dug 8 ft. sq. at the top and 15 ft. deep. A concrete footing course 5 ft. sq. and 6 ins. thick, was then put in the bottom. Iron dowel pins 1 in. in diameter and 10 ins. long were imbedded in this and allowed to protrude about 4 ins. above the footing course; these were so located that they came in the center of the well walls. On top of this footing course a concrete well was built 3 ft. sq., inside dimensions; the walls were 10 ins. thick at the bottom and 6 ins. at the top. Near the top of the well three bolts were imbedded on two opposite sides and to these were fastened 4 × 4-in. hardwood strips 3 ft. in length which are used as a support for the floor of the shelter. The shelter walls are 4 ins. thick and 6 ft. high. A door was provided on one side with dimensions 5 × 2 ft. This allows ready access to the gage and well.

The concrete mixture was 4 to 1 for footing course and the well walls up to within 2 ft. of the ground surface. For the upper 2 ft. of the well walls and the shelter a 3 to 1 mixture was used. Around the top of the shelter walls anchor bolts were set for the purpose of securing the roof, which is made of a double course of 1-in. boards, covered with galvanized sheet-iron. Two-inch round holes were left on opposite sides near the roof for ventilation.

A 4-in. cast-iron water pipe, 60 ft. in length, leads from the bottom of the well to the river. The intake end of the pipe is protected by a fine wire screen. This pipe is about 2 ft. below low water and as the bottom of the well is 12 ft. below ground surface it is believed the water in the well will never freeze. However, should any trouble be experienced on this account, it may be overcome by use of oil in the gage well. The intake and the well are located on the left bank, about 30 ft. down-stream from the cable.

The section of the river bed opposite this point was not changed, but was left rough in order to keep an open channel during the winter, if possible. On one side of the well three anchor bolts were fastened for use in securing a bed plank on which is placed a staff gage for checking observations on the recording gage. On the other side ¾-in. iron bolts, bent U shape, with square corners, were imbedded in the wall and spaced 18 ins. c. to c., vertically, to form a ladder giving access to the bottom of the well. This plan of construction is believed to be more desirable than the mere installation of a pipe for the float, as it permits of a thorough inspection of the gage and float at all times and also makes it possible to determine definitely whether the gage is making an accurate record. It is intended to install a hook gage on the bed plank in the well and to use the station as a place to make practical tests of recording gages. The time is not far distant when recording gages will be considered a necessary adjunct to all important stream-gaging stations.

COST.—It is believed that some statement of costs in connection with this work will be of interest to engineers who may have similar problems to contend with. Bearing in mind that the soil was of boulder hardpan and that the stream channel was unusually rough, the accompanying total may fairly be considered as a maximum charge in connection with this kind of work. The cost items, exclusive of the recording gage are as follows:

Clearing Channel:		
Explosives	$33.11	
Labor	167.34	
Sharpening drills	10.15	
Incidentals	5.20	
		$215.80
Cableway Equipment:		
350 ft. ⅝-in. galv.-iron cable	$14.53	
Turnbuckles and iron work for car	28.00	
Crosby clips and thimbles	2.23	
Lumber for A-frame and car	6.06	
Cement for pier and dead-man	7.70	
Labor on pier, A-frame and erection of cable	50.72	
Blacksmithing	13.97	
Freight	3.75	
Hardware	9.30	
Incidentals	8.23	
		144.49
Gage Well, Shelter and Intake:		
Cement	$23.70	
Lumber for forms, etc.	27.70	
Pipe for intake	20.01	
Excavation	196.94	
Laying Pipe	47.04	
Construction of well and shelter	165.12	
Freight	11.15	
Blacksmith	3.85	
Hardware	6.50	
Explosives	3.00	
Incidentals	19.93	
		524.94
Total		$885.23

The cost of a recording gage will amount to from $125 to $200, according to the type finally determined upon. Experiments are being conducted with two types of gages at the present time.

Considerable difficulty was experienced in keeping water out of the excavation for the gage well and in laying the pipe in the river bed. On account of a delay in securing supplies the work was not started until about the middle of September and it was finished about Nov. 5. Undoubtedly the cost would have been diminished if the work could have been done earlier in the summer when the weather conditions were more favorable. Another condition which materially increased the cost was that local laborers were not available.

The designing and construction of this equipment was done under the direction of the District Engineer of the U. S. Geological Survey at Albany, N. Y. Mr. John J. Phelan, Junior Engineer, had personal charge of the construction work.

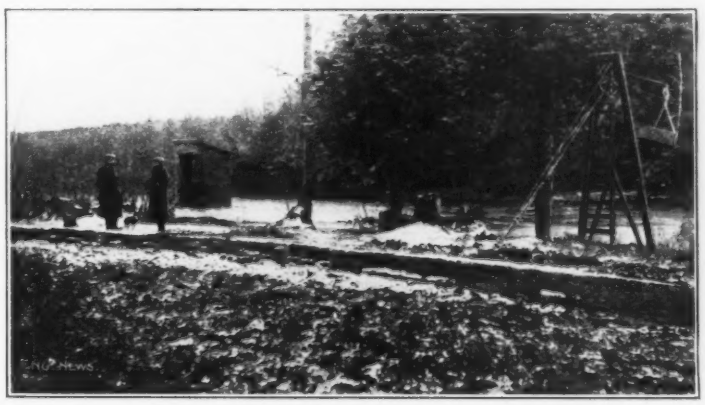

Fig. 4. A-Frame Anchorage, Gaging Car and Shelter House for Recording Gage.

Fig. 5. Standard Gaging Car, U. S. Geological Survey, in Use.

FIGS. 4 AND 5. VIEWS OF PERMANENT GAGING STATION ON SACANDAGA RIVER, NEAR HADLEY, N. Y.

Water-Power Plants and the Type Characteristic of Turbines.

By N. BAASHUUS.*

The type characteristic has been discussed on several occasions in the columns of this journal†, chiefly however from the standpoint of the turbine designer. As this quantity seems to merit some further attention, the following application of it to entire water-power plants and various parts thereof may be of interest‡.

Water-power plants always comprise two, but generally three lines of engineering, namely: civil, mechanical and electrical engineering. It is given to only few to master all these lines, each of which is just as important as the other ones for obtaining a successful result out of the development.

For those who are not conversant with the mechanical part (or more definitely, with turbines), the writer has adapted a method that might fairly well guide them as to some, at least, of the fundamental questions.

The two primary factors, quantity of water and head available, having been determined, the questions about the turbines are: Selection of system and type, of capacity, of revolutions per minute, and determination of space required for installation. Even an approximate answer will be sufficient so far as *preliminary projects* are concerned, and to the latter only the following method is limited.

Assuming an efficiency of the turbines of 80%, the total capacity of the plant, HP_1, is given by:

$$HP_1 = \frac{Q \times H}{11},$$

where Q = quantity of water in cu. ft. per sec., and H = effective head in ft.

This total capacity in most cases is subdivided into several units according to the purposes for which the power plant is to be built. As a general rule the number of units should be kept as low as possible, as the cost is thereby reduced. But where water is scarce during the dry season this principle cannot be maintained, because it would not be consistent with an economical utilization of the water. The reason for this is that the reduced quantity of water would have to be utilized in units running at partial load, under which conditions the efficiency of most turbines drops considerably.

In subdividing the total capacity, provision should be made for either immediate or future installation of a reserve unit. For it must always be borne in mind that water-turbines have to utilize a medium which is more or less mixed with foreign matters, such as ice, branches, etc., and therefore need inspection and repairs.

The two turbine systems now in use are the radial inward-flow turbine and the impulse wheel. The first one is generally used for heads between about 5 ft. and 500 ft. The second system is generally used for heads between about 300 ft. and 3,000 ft. While there is no doubt as to the system proper for very low or very high heads, there is a certain intermediate range for which the most suitable system cannot be determined at once. This range is, as the above figures indicate, generally between 300 and 500 ft., but in many cases it may extend beyond these figures. By means of the type characteristic K_t, turbines within this range can be determined.

Let HP be the capacity of a single turbine unit, in horsepower; N the speed of the turbine in revolutions per minute; and H the effective head at the turbine casing, in feet; then combine these quantities to the following term:

$$K_t = \frac{N}{H}\sqrt{\frac{H\,P}{\sqrt{H}}},$$

in which form it can easily be read off every slide-rule.

In applying this term to turbines already built it will be found that the data of a radial inward-flow turbine give a high type characteristic, between 10 and 100, while the data of an impulse wheel give a low figure, between 1 and 5, or even lower. Practically, the type characteristic will always be within these limits, no matter of what capacity, speed, head, size or design the turbine is. It must, however, be understood that where an inward-flow turbine has more than one runner, or where an impulse wheel has more than one nozzle, the horsepower to be applied in the formula for the type characteristic is the power developed by *one runner* only, or *one nozzle* only.

The type characteristic being derived from the fundamental laws of turbine design*, it follows that the application of this term leads to just as true results as do these laws themselves.

An example will at once show the practical value of the aforesaid. Suppose that preliminary investigations of a power site have shown an available effective head of 324 ft. and an available flow of about 310 cu. ft. per sec., then the total capacity is:

$$HP_1 = \frac{324 \times 310}{11} = 9100$$

Of this amount about 100 HP. will be required for exciters and lighting purposes, and there would be installed two exciter units of 100 HP. each, running at 550 r. p. m., one being a reserve unit. The remaining 9,000 HP. would be subdivided into three units of 3,000 HP. each, running at 500 r. p. m., with a fourth unit as a reserve.

With the above data we find the type characteristic of the main units to be:

$$K_t = \frac{500}{310}\sqrt{\frac{3000}{\sqrt{310}}} = 21.$$

Consequently in this case a turbine of the radial inward-flow system has to be used, as K_t is between 10 and 100.

Likewise for the exciter unit find:

$$K_t = \frac{550}{310}\sqrt{\frac{100}{17.6}} = 4.25$$

Consequently an impulse wheel has to be used for driving the exciter generator, as its K_t is between 1 and 5.

But the type characteristic is able to tell more about the turbines than merely their system. As will be seen the term contains only the two quantities speed and capacity for a certain head. But as these quantities determine the areas and angles of the turbine, and thereby again the losses which take place during the passage of the water through the turbine, it will be understood that the type characteristic is inherently related to the *efficiency* which can be expected from the turbine. In Table I, below, practically all different types of radial inward-flow turbine are represented by their type characteristics, and for each group is given the efficiency.

A glance at the table shows that the different types of radial inward-flow turbine are of different qualities. The low-speed turbines are very favorable as to efficiency over a wide range of loads. However, they are practically limited to high heads. Medium-speed turbines are also very favorable as to efficiency over a wide range of loads. High-speed turbines are favorable as to efficiency at about 0.8 load, but show a marked decrease at about half load. The extreme high-speed turbines may in some cases be tolerable as to efficiency at about 0.9 load, but at about half load the efficiency is below the limit of rational utilization of the water. The use of such turbines is only justified for low heads, with a supply of water ample in all seasons, and where the head remains rather constant.

TABLE I.—CLASSES OF RADIAL INWARD-FLOW TURBINE AND THEIR EFFICIENCIES.

Type.	K_t*	Efficiency.†
Low-speed turbine	10 to 20	Maximum, 82% at ¾ power; 76% at ½ power
Medium-speed turbine	30 to 50	Maximum, 82% at ¾ power; 75% at ½ power
High-speed turbine	60 to 80	Maximum, 80% at ⁸/₁₀ power; 70% at ½ power
Very high-speed turbine	90 to 100	Maximum, 73% at ⁹/₁₀ power; 53% at ½ power

*K_t refers to the maximum power of one runner only. In cases where the type characteristic is higher than 100, multiplex turbines have to be used.

†At maximum power the efficiences are a few per cent. lower than the maximum efficiencies.

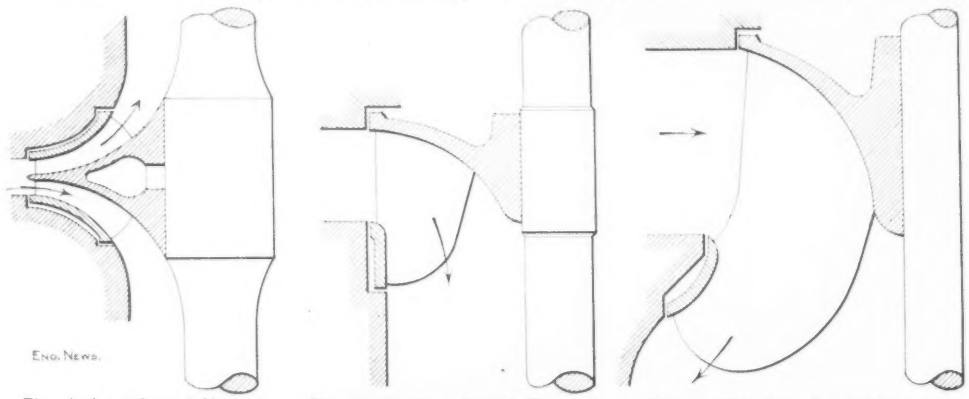

Fig. 1. Low-Speed Turbine; $K_t = 10$.

Fig. 2. Medium-Speed Turbine; $K_t = 35$.

Fig. 3. High-Speed Turbine; $K_t = 70$.

FIGS. 1-3. RUNNERS OF DIFFERENT TYPES OF RADIAL INWARD-FLOW TURBINE.

The differences of design of various types of radial inward-flow turbines are shown in the accompanying illustrations, Figs. 1 to 3, which show sections through three runners of the same diameter. The low-speed turbine is characterized by small width at entrance and small diameter of draft-tube at exit; the illustration shown is the runner of a double turbine. The medium-speed turbine shows a considerable enlargement of width and draft-tube diameter. This enlargement is carried out still more in the case of the high-speed turbine.

The figures of Table I are approximate, of course, and many turbines have been tested which gave better results. Also skilled turbine designers are able to slightly modify the location of the point of maximum efficiency. But as a common denominator of what can be expected from turbines of the many different makes (proper setting and installation being assumed), the figures of the table may satisfy the purposes of this article. In cases where the head is subject to great variations, however, the question of selecting the most favorable type, or types, becomes a very difficult matter, and an expert turbine engineer should be consulted.

In selecting the type for a proposed turbine plant, the capacity and revolutions can be chosen in such a way that turbines of high efficiency are secured. In cases of low head, however, the turbines then would run too slow for most purposes, and necessitate too great expense. This disadvantage can be met by the use of multiplex turbines, i. e. by keying several runners to the same shaft. For instance, a dynamo of 750 HP. and 257 r. p. m., is to be driven by a turbine under 36 ft. effective head. The type characteristic is:

*Hydraulic and Mechanical Engineer, 187 Delaware Ave., Toronto, Ont.

†See "A Comparison of American High-Speed Runners for Water Turbines," by S. J. Zowski, Eng. News, Jan. 28, 1909, pp. 99-102; "Tests of a High-Efficiency High-Speed Hydraulic Turbine Runner," by E. Reichel, Eng. News, Sept. 9, 1909, p. 286; "A Rational Method of Determining the Principal Dimensions of Water-Turbine Runners," by S. J. Zowski, Eng. News, Jan. 6, 1910, pp. 20-24; and "The Type Characteristic of Impulse Wheels and Its Use in Design," by S. J. Zowski, Eng. News, Feb. 10, 1910, pp. 165-168.

‡This article is based on an article by the author in "Elektrotechnische Zeitschrift, 1905, p. 961, and considerable new matter.

*See "Zeitschrift des Vereines Deutscher Ingenieure," 1905, p. 93, and Eng. News, 1909—II., p. 99.

$$K_t = \frac{257}{36}\sqrt{\frac{750}{6}} = 80.$$

This corresponds to a high-speed turbine. If, in the case of this development, water is scarce during the dry seasons, it is better to use a double turbine; the power of each runner being then only 375 HP., the type characteristic is:

$$K_t = \frac{257}{36}\sqrt{\frac{375}{6}} = 56.5$$

With this type the utilization of the water takes place in a more economical way, as Table I indicates.

If the requirements as to efficiency are still higher, a quadruple turbine can be used. Its type characteristic in the present case would be:

$$K_t = \frac{257}{36}\sqrt{\frac{187.5}{6}} = 40,$$

which represents an inward-flow turbine of the most favorable type as to efficiency.

In the same way the type characteristic can also classify the different types of impulse wheels. In Table II practically all different types of this system are represented by their type characteristics, and for each type is given the efficiency.

TABLE II.—IMPULSE WHEELS AND THEIR EFFICIENCIES.

K_t* =	1	2	3	4	5
Efficiency at about ¾ power† =	80	79	78	77	76%

*K_t refers to the maximum power of one nozzle only. In cases where the type characteristic is between 5 and 10, turbines with more nozzles than one have to be used.
†At maximum and half power the efficiencies are a few per cent. lower.

The figures of Table II are approximate in the same way as those of Table I.

In order to secure a high number of revolutions at a desirable efficiency, or a high efficiency at a desirable number of revolutions, the jets of several nozzles can be arranged to act on one runner, and also several runners can be keyed to the same shaft. For instance, under 400-ft. head a turbine is to develop 1,300 HP. at an efficiency of not less than 78%. According to Table II a turbine with a type characteristic of about 3 has to be used. Then the number of revolutions with a single turbine is:

$$N = K_t \times H \times \sqrt{\frac{H}{N}} = 3 \times 400 \times \sqrt{\frac{20}{1300}} = 150.$$

If this is too slow, two nozzles can be arranged to supply the water to the runner. Each nozzle then supplies only half of 1,300 HP., and the corresponding number of revolutions is:

$$N = 150 \times \sqrt{2} = 212.$$

With four nozzles acting on two runners the number of revolutions is:

$$N = 150 \times \sqrt{4} = 300,$$

and with 6 nozzles acting on three (or even only on two) runners the number of revolutions will be:

$$N = 150 \times \sqrt{6} = 367.$$

Because K_t is the same in all these cases, the efficiency will be practically the same (78%) for all of them, with proper setting, although the dimensions and the number of revolutions differ very much.

Determining Principal Dimensions.

The above refers to the determination of the types only. The following method of determining the *principal dimensions* of turbines may in some cases be useful.

Most firms have standard types of turbines. The different sizes of the same type have approximately the same angles and proportional areas, and therefore also the same type characteristic, no matter under what head they operate. All dimensions of these turbines can be expressed as functions of the diameter of the runner, and these functions are practically the same for all sizes of the same type. For instance, if the diameter of the runner of a certain turbine is 39 ins., and the diameter of its flume (casing) is 82 ins., then the diameter of the flume of a turbine with a runner of 32 ins. is $\frac{32}{39} \times 82 = 67$ ins. In the same way, if the length of the flume (casing) of the first turbine was 170 ins., the length in the second case would be 140 ins. But in a general way the same can also be said concerning the constructions of inlet and discharge, the means for shutting off, and to some extent also concerning the means for regulation of the turbine, in other words for the whole turbine plant. Now, in books and reviews there are many detailed descriptions, with drawings to scale, of turbine plants. Each of these, for our purposes, can be considered as a certain size of a type of whole plants which is distinguished by its type characteristic, and the other sizes of which are similar to that pattern, and can be obtained by linear enlargement or diminution.

If a turbine plant with turbines of a certain type characteristic K_t is proposed, then the descriptions of turbines of approximately the same type characteristic are to be looked up. If among these there is a plant which was built in the same way as natural conditions dictate the new plant to be built, and if that plant has given satisfactory results, then it can be taken as starting point for the determination of the size of the new plant. Nothing more is required for this purpose, as mentioned above, than a knowledge of the ratio between the runners of the two plants. The dimensions of the runners will not always be known from these publications. But the following property of standardized turbines of the same type, namely that the diameters are proportional to the fraction $\frac{\sqrt{H}}{N}$, will always allow of the determination of the ratio between the diameters without knowing the size of them.

Some examples will explain the method.

EXAMPLE.—We will suppose that the project is for a power-house with three turbines on horizontal shafts, two runners per turbine, in steel casing, developing 1,250 HP. per unit (625 HP. per runner), under an effective head of 39 ft., and running at 257 r. p. m. The type characteristic, for a twin turbine, is

$$K_t = \frac{250}{39}\sqrt{\frac{1250}{2 \times 6.25}} = 66$$

Next, turbines of the same construction and type characteristic are looked up in engineering literature and in past bids; we will suppose that the plant shown in Fig. 4 is thus found. The type characteristic of its turbines is 64, which is close enough to the figure 66 computed for the turbines of the projected plant.

The ratio between the sizes of these two turbines is:

$$\frac{D_2}{D_1} = \sqrt{\frac{H_2}{H_1}} \times \frac{N_1}{N_2} = \sqrt{\frac{39}{53}} \times \frac{360}{257} = 1.2$$

Consequently all dimensions of the turbines of the new plant are 1.2 times the corresponding ones of the other (see Fig. 5). For instance, the floor space of the old turbines is 10 ft. by 23 ft. 6 ins. The floor space of the new turbines is 1.2 × 10 ft. by 1.2 × 23 ft. 6 ins., or 12 ft. by 28 ft. 3 ins. And if the size of the generators can be supposed to increase in approximately the same proportion, then the area of the power-house, which for the old plant is 50 ft. × 70 ft. = 3,500 sq. ft., will be increased to about 1.2 × 50 ft. by 1.2 × 70 ft. = 60 ft. by 84 ft. = 5,000 sq. ft.

This method of determining dimensions is of course an approximate one, and it is therefore advisable to increase the obtained results somewhat, in order to be on the safe side. Also exaggerations should be avoided, such as attempting to derive the dimensions of a 1,500-HP. turbine from those of a turbine of 50 HP., or using

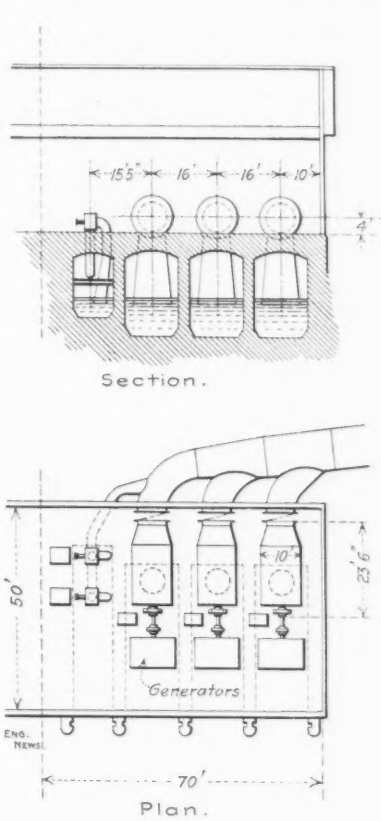

Fig. 4. Plant 1.

Effective head, H = 53 ft.
Capacity per unit, HP = 1,300 HP. (2 runners).
Speed, N = 360 r. p. m.

Type characteristic, $K_t = \frac{360}{53}\sqrt{\frac{1,300}{2 \times 7.28}} = 64$

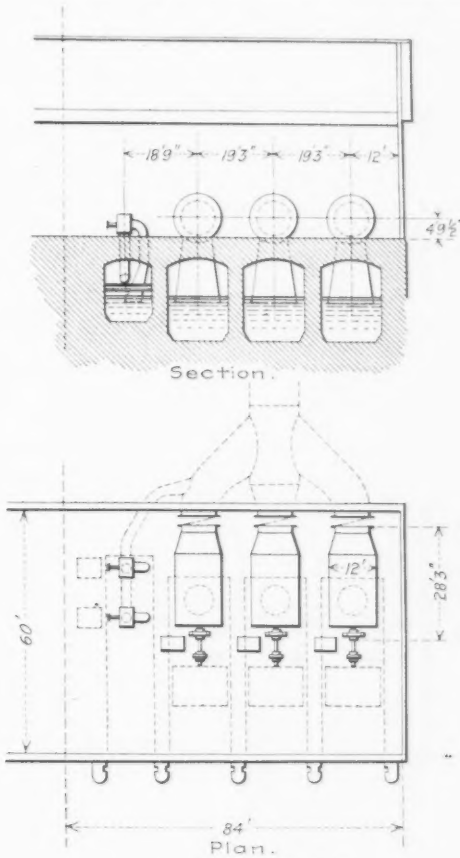

Fig. 5. Plant 2.

Effective head, H = 39 ft.
Capacity per unit, HP = 1,250 HP. (2 runners).
Speed, N = 257 r. p. m.

Type characteristic, $K_t = \frac{257}{39}\sqrt{\frac{1,250}{2 \times 6.25}} = 66$

Ratio of sizes $\frac{D_2}{D_1} = \sqrt{\frac{39}{53}} \times \frac{360}{257} = 1.2$

FIGS. 4-5. DETERMINATION OF DIMENSIONS OF A WATER-POWER PLANT FROM THOSE OF ANOTHER OF SAME TYPE CHARACTERISTIC.

the dimensions of a 15-in. turbine for estimating the dimensions of an 80-in. turbine.

ESTIMATING THE WEIGHT OF A TURBINE.—In this connection it may, perhaps, be of some interest to deal with the preliminary determination of *weights* of turbines, even though only in a very approximate way. In the literature of the subject, statements of weights will be found but rarely. However, all consulting engineers possess tenders which can be used for this purpose.

If designed for the *same head*, turbines of the *different sizes* of a standardized series will have weights approximately proportional to a function of the ratio of diameters:

$$\frac{W_2}{W_1} \quad \text{from } \left(\frac{D_2}{D_1}\right)^{\frac{5}{2}} \text{ up to } \left(\frac{D_2}{D_1}\right)^{3}$$

The first value should be used where $\frac{D_2}{D_1}$ is less than 1, and the second where $\frac{D_2}{D_1}$ is greater than 1.

For *different heads* the weights of turbines of the *same size* are approximately in the proportion:

$$\frac{W_2}{W_1} = \text{from} \left(\frac{H_2}{H_1}\right)^{\frac{2}{3}} \text{up to} \left(\frac{H_2}{H_1}\right)^{1}$$

The first value should be used where $\frac{H_2}{H_1}$ is less than 1, and the second where $\frac{H_2}{H_1}$ is greater than 1.

EXAMPLE 1.—For instance, if we know the weight W_1 of a turbine of 1,000-HP. capacity running at a speed of 300 r. p. m. under an effective head of 105 ft., then the weight W_2 of a turbine of the same type characteristic (28) developing 750 HP. under 67.5 ft. effective head at 200 r. p. m. can be figured out as follows:

$$\frac{D_2}{D_1} = \sqrt{\frac{H_2}{H_1}} \times \frac{N_1}{N_2} = \sqrt{\frac{67.5}{105}} \times \frac{300}{200} = 1.2$$

$$\frac{H_2}{H_1} = \frac{67.5}{105} = 0.64$$

$$W_2 = 1.2^3 \times \sqrt[3]{0.64^2} \times W_1 = 1.3\ W_1 \text{ approx.}$$

EXAMPLE 2.—In another case the weight of a 1,000-HP. turbine running at 300 r. p. m. under an effective head of 500 ft. is W_1. Then the weight W_2 of a turbine of the same type characteristic (4), developing 1,500 HP. under 815 ft. effective head at a speed of 450 r. p. m. can be figured out as follows:

$$\frac{D_2}{D_1} = \sqrt{\frac{815}{500}} \times \frac{300}{450} = 0.85\ ,$$

$$\frac{H_2}{H_1} = \frac{815}{500} = 1.63\ ,$$

$$W_2 = .85^2 \times \sqrt{.85} \times 1.63 \times W_1 = 1.1\ W_1 \text{ approx.}$$

As mentioned above, the method of determining the weights is a very approximate one. And where the known turbine and the turbine derived from it are very different as to size the method is not applicable at all. But, nevertheless, the method in some cases is able to give an approximate idea as to the weight. And as the prices are based upon the weights, it is also possible to form an idea about the price of a proposed turbine. Where $\frac{D_2}{D_1}$ and $\frac{H_2}{H_1}$ are not very different from unity the prices are simply proportional to the weights.

As pointed out above the methods which are the subject of this article are of an approximate nature and, therefore, they should be limited to preliminary proposals. The use of the methods supposes a certain stock of descriptions and drawings of water-power plants, which can be found in reviews, books and tenders. But it is to be borne in mind that many so-described plants are of special design owing to particular natural conditions of their site. Also it must be remembered that many a plant which shortly after being set in operation gave a good result may not have proved to be a lasting success. In spite of these limiting factors the above methods, when used with caution and judgment, may prove to be of some use and may save much time and correspondence.

Methods of Taking Traffic Census on Highways.*

By ARTHUR H. BLANCHARD,† M. Am. Soc. C. E., and IRVING W. PATTERSON,‡ Jun. Am. Soc. C. E.

The inherent value of statistics relative to traffic on state trunk lines and county main roads, obtained previous to construction, is recognized by all engineers who are familiar with the problems of modern highway engineering and who take into careful consideration the economics of the construction and maintenance of highways. Various classifications of the traffic to which the above classes of highways are subjected have been proposed from time to time during the past few years, but the methods to be employed in securing a satisfactory traffic census have not been made the subject of extended discussion in the technical press.

The principles underlying the essential elements of any classification of traffic may be stated briefly as follows: (1) differentiation between horse-drawn-vehicle traffic and motor-car traffic; (2) a division of each of these classes of traffic into pleasure and commercial traffic; (3) a subdivision of commercial traffic into loaded and unloaded vehicles; (4) the determination of the weight per linear inch of width of tire of all types of commercial traffic, a factor of the utmost importance in the design of the substructure of the road; (5) a subdivision of the two classes of horse-drawn-vehicle traffic dependent upon the number of horses; (6) subdivision of pleasure motor-car traffic upon the basis of weight and speed, since in many instances the greatest damage to an ordinary macadam road is caused by seven-seat touring cars, limousines or landaulets traveling at speeds of 40 to 60 mi. per hr; (7) provision for extraordinary character of local traffic—for example, in certain localities many saddle horses may use the public road; in others, traction engines hauling trailers may be common, while in others motor-bus traffic may be a regular and important feature; (8) as a final illustration, special types of commercial traffic, such as ice wagons, mill drays, etc., may be influential features.

As an integral part of the requisite investigation preliminary to economical and efficient design, other facts relative to traffic should be obtained; as, for example, the direction of the traffic, the portion of the road occupied by various kinds of traffic, the relationship existing between reduced grades incurring increased distance between two points and probable traffic, the kind of the shoes worn by horses at various seasons of the year, the use of non-skidding devices employed by motorists and the enforced traffic regulations governing the use of the road, especially with reference to limitations upon speed and loads to be carried.

In connection with the preliminary investigations, an engineer must always consider the change in the character and amount of traffic that is liable to occur after the improvement of a road. The importance of an estimate of probable traffic cannot be overemphasized. As an example may be cited the marked change in the character of the traffic resulting from the construction of a bituminous pavement on a trunk line between two towns in Rhode Island. Two trunk lines have been nearly completed between the two towns in question: one of ordinary macadam oiled at intervals during the summer, the other as described above. The route of ordinary macadam is three-fourths of a mile shorter than the new route, but, nevertheless, the longer route of a total of three miles is the more popular with the motorist for several reasons, which may be designated as follows: (1) less opportunity of meeting horse-drawn-vehicle traffic; (2) superior road from an esthetic standpoint; (3) better road surface. There exist cases where the change in the character of or the unusual increase in traffic after the construction of a road renders unwarranted the securing of comprehensive traffic data previous to construction. By the careful preliminary investigation of such cases, the engineer will be able to determine the method to be employed in order to secure the requisite traffic census data for the design of the road.

Before considering the methods by which the necessary traffic census may be obtained, various typical classifications of traffic and other details relative thereto which have been published during the past decade will be given, as a thorough study of the information thus presented will furnish food for thought in connection with local problems.

Before the recognition of the motor car as an important factor in highway traffic, the following classifications were published in this country.

CLASSIFICATION USED BY THE OFFICE OF PUBLIC ROAD INQUIRIES.

Loaded 1-horse wagon.	Unloaded 4-horse wagon.
Unloaded 1-horse wagon.	1-horse pleasure vehicle.
Loaded 2-horse wagon.	2-horse pleasure vehicle.
Unloaded 2-horse wagon.	Rubber-tired vehicle.
Loaded 4-horse wagon.	Unharnessed horse or shod ox.

Excessively heavy vehicle (such as carries ore, stone, brick, timber, etc.).

Relative to the method of securing the volume and character of traffic, the following information is given: "Less than a week's record is unsatisfactory, and it is best that the record should cover as many seasons of the year as possible." The directions also call for each record to cover 24 consecutive hours.

Mr. A. N. Johnson, State Highway Engineer of Illinois, in 1906 employed a classification of horse-drawn-vehicle traffic based on a distinction between the traffic going towards important towns and traffic going from towns and a subdivision into loaded and unloaded vehicles. A further subdivision of the traffic was based upon the number of horses employed. He stated:

In winter the traffic was recorded during the daylight hours, in other seasons of the year from 6 a. m. to 6 p. m. The days were so selected that if the first count came on a Monday, the next would come on Tuesday of the following week, Wednesday of the next week, and so on.

Since the advent of the motor car, the traffic classifications have undergone a transformation. One of the most comprehensive which has been noted is the preliminary form proposed by the new Road Board of England. The classification includes the following list of vehicles:

CLASSIFICATION OF THE BRITISH ROAD BOARD.

Tramcars (electric, steam or horse).
Motor Vehicles:
- Ordinary motor cars (including cabs).
- Motor omnibuses.
- Motor delivery vans.
- Heavy motor lorries.
- Tractors or traction engines (trailers are to be counted as additional vehicles, e. g., a traction engine with two trailers would be entered as 3).
- Motor bicycles and tricycles.
- Any other motor vehicles not included in any of the above heads.

Horse-drawn Vehicles:
- Omnibus (including public service and hotel).
- Two-wheeled vehicles (one horse).
- Two-wheeled vehicles (two horses or more).
- Four-wheeled vehicles (one horse).
- Four-wheeled vehicles (two horses or more).

Other Traffic:
- Ordinary bicycles and tricycles.
- Herds of cattle (if more than 5 in number) to be entered as 1.
- Flock of sheep and pigs (if more than 5 in number) to be entered as 1.
- Horses (led or ridden).

In the United States the following classifications have appeared either in reports or in the technical press:

Loaded 1-horse wagon.	Saddle horse.
Unloaded 1-horse wagon.	Excessively heavy vehicle (such as carry ore, stone, timber, machinery, etc.).
Loaded 2-horse wagon.	
Unloaded 2-horse wagon.	
Loaded 4-horse wagon.	Motor runabout.
Unloaded 4-horse wagon.	Motor touring car.
One-horse pleasure vehicle.	Loaded motor dray.
Two-horse pleasure vehicle.	Unloaded motor dray.
Motor cycle.	

Less than a week's record is unsatisfactory, and it is best that a record should cover as many seasons of the year as possible.

The classification employed by the State Highway Commission of Massachusetts in 1909 was as follows:

MASSACHUSETTS STATE HIGHWAY COMMISSION.

Single horse, light vehicles.
Single horse, heavy vehicles.
Two or more horses, light vehicles.
Two or more horses, heavy vehicles.
Automobiles, touring cars.
Automobiles, runabouts.

Light vehicle covers buggies, democrat wagons, or any other vehicle used for pleasure or light business purposes; heavy vehicle designates farming wagons, milk wagons, tip carts, grocery or provision wagons, or any other vehicles except autos which are used for carrying heavy loads.

The Massachusetts traffic census was taken in two-hour periods consecutively from 7 a. m. to 9 p. m. Two sets of observations were made, one covering a week in August, the other a week in October.

In 1909 the New York State Highway Commission had a traffic census taken upon the county highways built by state aid at four different periods. A traffic census was also taken in 1909 on state and county roads which would probably be built in 1910. The classification adopted was as follows, relative weights being given to different types of traffic:

*A paper presented before Section D of the American Association for the Advancement of Science at the Minneapolis meeting, Dec. 29, 1910.

†Professor, Department of Civil Engineering, Brown University, and Consulting Engineer, Providence, R. I.

‡Assistant Engineer with A. H. Blanchard, Providence, R. I.

NEW YORK STATE HIGHWAY COMMISSION.

Horse-drawn Vehicle.	Relative Weight.
Horse, without vehicle	1
One-horse vehicle, light	2
One-horse vehicle, heavy	3
Two-horse vehicle, light	3
Two-horse vehicle, heavy	4
Three-horse vehicle, heavy	5
Four-horse vehicle, heavy	6
Motor Vehicles:	
Motor cycle	1
Two-passenger car	2
Three-passenger car	3
Four-passenger car	4
Five-passenger car	5
Six-passenger car	6
Seven-passenger car	7
Freight trucks, omnibuses, etc.	10
Miscellaneous:	
Traction engine	15
Two-traction engine	30
Miscellaneous heavy traffic	5 upward

The records were made by multiplying the traffic units by relative weights and noting the two subdivisions, horse and motor.

The classification employed by the Rhode Island State Board of Public Roads during 1908 and 1909 was as follows.

RHODE ISLAND STATE BOARD OF PUBLIC ROADS.

Motor car traffic:
- Runabouts.
- Touring cars, four or five seats.
- Touring cars, six or seven seats, including limousines and landaulets.
- Motor cycles.

Horse-drawn vehicle traffic:
- Commercial traffic—
  - One-horse wagon, loaded, iron tires.
  - One-horse wagon, loaded, rubber tires.
  - One-horse wagon, unloaded, iron tires.
  - One-horse wagon, unloaded, rubber tires.
  - Two-horse wagon, loaded, iron tires.
  - Two-horse wagon, loaded, rubber tires.
  - Two-horse wagon, unloaded, iron tires.
  - Two-horse wagon, unloaded, rubber tires.
  - Other wagons, loaded.
  - Other wagons, unloaded.
- Pleasure vehicle traffic—
  - One-horse vehicle, iron tires.
  - One-horse vehicle, rubber tires.
  - Two-horse vehicle, iron tires.
  - Two-horse vehicle, rubber tires.

In a form covering "Data Concerning the Use of Bituminous Materials in Road Surfacing" used in connection with the work of the Special Committee of the American Society of Civil Engineers on "Bituminous Materials for Road Construction" the following classification was adopted:

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Horse-Drawn Vehicle Traffic:
- One-horse vehicles.
- Two-horse vehicles.
- Three-horse vehicles.
- Four-horse vehicles.
- Five-horse vehicles.
- Six or more horse vehicles.

Motor-Vehicle Traffic:
- Motor cycles.
- Motor runabouts
- Motor touring cars (four or five seats).
- Motor touring cars (six or seven seats) including limousines or landaulets.
- Motor wagons or drays.

By means of columns a further division of the above classes of traffic is called for under the headings, empty vehicles, loaded vehicles and passenger vehicles. A column is also provided for an estimate in pounds of the maximum load per inch of tire.

In the new form recently issued in connection with the work of the above-named Committee covering a "Report on Results of the Use of the Bituminous Materials in Road Construction" two sets of records are called for, one covering the period from November to March, the other from April to October.

After the classification of the traffic has been adopted, the methods of securing traffic data must be considered from many standpoints before a final decision is reached.

The method selected will be influenced by the amount of time at the disposal of the engineer and the character, amount and distribution of the traffic to which the road in question is subjected. In case the location of the roads to be built in a given period is known over a year in advance of construction, a comprehensive plan covering observations throughout the year should be adopted in order to secure complete information. In many instances, however, perhaps only a month will be available in which to make investigations preliminary to design. The above cases will be taken as the extremes and methods will be discussed which are applicable to each. In either case it is essential that as complete information as possible should be secured relative to the nature of the traffic on any given road before a plan is adopted. As the primary object of any traffic census is to secure data covering both normal and abnormal traffic of all classes, it is essential to incorporate in a plan definite provision for securing the above information rather than depending upon a haphazard selection of days to furnish the facts. As an illustration of varying local conditions may be cited: exceptional horse-drawn vehicle traffic, consisting of produce wagons, between the hours of midnight and 6 a. m. during certain seasons of the year; market days, fair days and other special events in connection with which both pleasure and commercial traffic may be excessive; periodical heavy shipments by special industries using the road in hauling raw material or in shipping the manufactured article; through traffic at certain periods of the day, week or year as, for example, motor-car traffic between residential communities or summer colonies and cities. After having obtained all the information of this nature it is possible to glean from local sources, the next step is the consideration of the most economical plans to be adopted in order to secure the essential data.

As a specific illustration, a road in the northeastern part of the United States will be considered, presupposing that a year is available in which to make observations. In many cases it is essential to obtain the following: normal winter traffic, normal summer traffic and abnormal summer motor-car traffic. It should be borne in mind that from the standpoint of the proper design of the road, it is necessary to know approximately the total yearly traffic, which is a function of both the normal and the abnormal traffic, and also the amount of abnormal traffic of various types at different periods of the year.

Three plans for taking a traffic census throughout the year covering the usual conditions will be considered. Two of these plans at once suggest themselves: (1) to take the traffic in periods of six or seven consecutive days and (2) to distribute the recording days throughout a given season by starting on a given day of the week, for example a Monday, then take the traffic on the Tuesday of the following week or at an interval of 15 days, and so on during the season. The merits of the two schemes will be considered from two standpoints, efficiency and economy.

With reference to the season between April and October, the months of April, May, June, September and October may usually be considered as normal while July and August will generally cover the periods of excessive motor-car traffic. The adoption of the first plan suggested would necessitate a minimum of one period of six or seven days in the normal months and one period in one of the abnormal months, preferably in August. It should be noted that both the normal and abnormal Saturday and Sunday traffic are ascertained by only one set of observations in each case. A self-evident and unsatisfactory result of this plan if only two periods are to be taken. If more than two periods are advocated the expense entailed would be considered prohibitive. The second plan is open to all the objections raised against the first and would prove more expensive provided enough days were used to secure an equal amount of information.

As a practical, economical and efficient plan the following method is proposed for adoption under average conditions. For the season from April to October, inclusive, the traffic should be taken during four periods of three days each; one period being in April, May or June, one in July, one in August and one in September or October. As local conditions may dictate, either Friday, Saturday and Sunday, or Saturday, Sunday and Monday, could be taken, thus ensuring information relative to the usual abnormal Sunday motor-car traffic and, in some cases, to traffic above the week-day average on Saturdays, while the Friday or Monday traffic would give a fair indication of the normal week-day traffic. It is evident that by this plan more reliable and essential facts are secured relative to traffic than by the other methods considered. From the standpoint of economy the advantage lies entirely with the proposed method, especially if the lowest-paid members of the engineering department are employed on this work. Week-end trips involving the use of only 1½ working days for the taking of the census during each period is a particularly satisfactory arrangement from the standpoint of the economical use of office time.

In connection with this method it is of interest to note certain facts which have been ascertained relative to climatic conditions in the three-day periods considered. The figures given are based on data furnished relative to Providence, and cover the years from 1905 to 1909, inclusive. In the periods of the season from April to October in the five years mentioned only one period of three consecutive rainy days occurred or, in other words, one such period occurred in a total of 152 periods. A period with two rainy days occurred once in 25 periods, while a period with one rainy day occurred once in three periods. Furthermore, with reference to abnormal motor-car traffic periods in July and August, there was, in the five years considered, no period with either three consecutive rainy days or a period with two rainy days, while a period with one rainy day occurred once in three periods. It is obvious, therefore, that climatic conditions are favorable to the adoption of the plan proposed.

In the months from November to March, inclusive, two three-day periods would be taken in certain cases; one in November or December, the other in February or March. This distribution of the periods would furnish statistics of the normal traffic in this season and would also afford opportunity for a study of traffic detail and the condition of the road during the winter season.

Instead of having the results of a year's observations upon which to base a design of a given highway, in many cases only a month will be available in which to make all the preliminary investigations. This extreme case will be discussed as a type of a short-period investigation. Three plans will be considered: (1) a period of nine consecutive days, beginning with a Saturday and ending with a Sunday; (2) nine days of observations, distributed as follows: Saturday, Sunday and Monday of the first week, Tuesday of the second week, Wednesday of the third, Thursday of the fourth, and Friday, Saturday and Sunday of the fifth week; (3) a plan of three-day periods, using three sets, one of Friday, Saturday and Sunday and two of Saturday, Sunday and Monday, one period in the first week, one in the third and one in the last week. It is obvious for the same reasons as in the former comparison that the advantage lies with the third method. From the standpoint of the Saturday and Sunday traffic, the third plan provides an average of three days, the first and second an average of two days, without much opportunity for extra periods if the weather should prove inclement on abnormal traffic days. Although the first and second give more complete information relative to normal week-day traffic, it is usually unnecessary to take traffic on more than six week days in order to secure satisfactory data relative to normal traffic in a given month.

As the relationship existing between the various methods considered and climatic conditions has an important bearing upon the final selection of a plan, the following information is presented for consideration. The months which will usually be used for short-period observations are from March to August, inclusive. The following data for the years 1905 to 1909, inclusive, has been ascertained relative to the first method of taking nine consecutive days in the middle of the months mentioned. In a total of 30 periods 25 contained at least one rainy day, 13 at least two rainy days, 4 at least three rainy days and 1 four rainy days. In the 30 periods there were seven rainy Sundays and ten rainy Saturdays, and in two periods both a Saturday and a Sunday were rainy. Hence it is obvious that in order to secure an average of the traffic on two Saturdays and two Sundays, it will be necessary in approximately one out of every two cases to take extra observations upon abnormal days.

For the second method, in which observations on week days are distributed throughout the month, the following data are interesting. In a total of 30 combinations, 27 combinations contained at least one rainy day, 15 combinations at least two rainy days, ten at least three rainy days and three combinations, five rainy days. In the 30 combinations there were 13 rainy Saturdays and 13 rainy Sundays, and in 7 combinations two Saturdays, two Sundays, or one Saturday and one Sunday were rainy. Here it is apparent that in 19 cases out of 30 it would be necessary to take extra observations in order to secure an average of the traffic on two Saturdays and two Sundays.

In the third method, of three periods of three days each, distributed throughout the month, in a total of 30 combinations of three periods, 25 contained at least one rainy day, ten contained at least two rainy days and three contained three rainy days. In the 30 combinations there were eleven rainy Saturdays and fifteen rainy Sundays, and in 7 combinations two Saturdays, two Sundays or one Saturday and one Sunday were rainy, two referring to two rainy Saturdays and one to two rainy Sundays. In only three instances, therefore, will it be necessary to take extra observations on Saturdays or Sundays to obtain the average of the traffic on two Saturdays and two Sundays. In 6 combinations out of 30 one rainy Friday occurred, but in no case more than one rainy Friday.

In view of the facts presented in the above discussion the third method is preferable both from the standpoint of the data secured and economy of time necessary to secure an average of the traffic on the abnormal days, Saturday and Sunday.

The number of consecutive hours which should be taken during the day will depend upon local conditions and the period of the year when observations are made. In many cases 24 hours will be absolutely necessary, while in certain cases 12 or 15 hours will be satisfactory. The engineer who makes the preliminary investigations will ascertain the number of hours requisite. It must be borne in mind that the facts ascertained are used as a basis for an estimate of traffic, and hence minute detail should not be obtained at unwarranted expense.

A NEW METHOD OF GROUTING IN QUICKSAND is described in "Zentralblatt der Bauverwaltung" of Feb. 11, 1911, by A. Wolfsholz. A pipe large enough to serve as cement injection tube is fitted at its lower end with an auger point and a helical screw blade; just above this blade several holes are drilled in the wall of the pipe, fitted for discharging grout outward over the upper surface of the blade. This boring apparatus is twisted down, if necessary with the help of jetting, by water pumped through the pipe. When it reaches the desired depth, grout is pumped into the pipe, and at the same time the drill is turned backward so as to withdraw it. The grout flows out along the face of the blade, and becomes mingled with the layer of sand above by the rotation; the resulting mixture is passed by the turning of the screw blade to the space below, where it builds up in a cylindrical body corresponding to the volume swept through by the blade. When the drill is wholly withdrawn, it may be sunk again alongside the first location, and thus a large mass of contiguous and coherent cylinders of the consolidated sand can be formed. The process is patented in Germany.

The Ventilation of Long Railway Tunnels.*

By RUDOLF HEINE.†

In many long tunnels the increasing traffic adds to the difficulties of ventilation due to unfavorable natural conditions. But even with comparatively light traffic, the natural ventilation may be impeded by unfavorable conditions as to grades, curves and the position of the entrances.

On the Austrian State Railways there are many two-grade tunnels (with a summit in the middle), and tunnels with steep grades and long curves. These tunnels tend to retain the smoke and to remain damp, so that they are in unfavorable condition for operating the traffic and maintaining the track. The Austrian Ministry of Railways therefore appointed a commission (in September, 1907) to investigate the subject and to report upon methods of improving the air in badly ventilated tunnels as well as upon projects for the artificial ventilation of individual tunnels. The tunnels investigated had maximum grades of 2 and 2.8%, or 3.5% in the tunnel of a rack railway.

In the tunnels where natural ventilation was at its worst, the tunnels were filled with smoke nearly continuously under unfavorable conditions of weather. The track inspection and maintenance work then became very difficult, and there were frequent cases of illness among the men at work in the tunnel. As the freight trains ascending tunnels with steep grades required extra locomotives for hauling and pushing them, the crew of the pusher suffered much from smoke and heat. Analyses of air collected in the tunnel and in the cab of the pusher showed a carbonic-acid content of up to 0.46% and a carbonic-oxide content of up to 0.81% in the most important unfavorable months; in addition sulphurous acid was found in the tunnel. The temperature in the cab often rose to 98.6° F.; in the Platten and Prebichl tunnels it even rose a few times to 133° and 140° F. in the summer months and when there was no wind.

The most evident measures for improving these conditions consisted in using powerful locomotives and reducing the weight of the freight trains. This made it possible to reduce the injurious slipping of the wheels in the tunnel and also to reduce the time taken in running through the badly-ventilated tunnel. As regards the firing in such tunnels, the inquiries lead to the following results:

(1) Coal containing sulphur should not be used in badly-ventilated tunnels, but only coal of best quality and with a high hydrogen content;

(2) Coke is quite unsuitable, as it burns with difficulty. The conditions for brisk, bright burning are absent in a tunnel, so that large quantities of carbonic-oxide and of hydrocarbons are produced;

(3) Great expectations were raised by the introduction of oil fuel in badly-ventilated tunnels. This gave fairly good results in the Arlberg tunnel, as no sulphurous acid and very little smoke are produced; if properly adjusted complete combustion results. Also, if a train has to stand still in the tunnel for some time, it is possible to stop the combustion.

The disadvantages are the high temperature of the gases, by which the crew suffers, and the fact that without careful manipulation (particularly if there is an excess of oil) the normal course of combustion is interfered with and the smoke conditions become worse (greater production of carbonic oxide) than if coal is used. The tarry products which are deposited from the gases have a deleterious influence. It was particularly noticeable in the Arlberg tunnel, that rails, which had not been used for some time, became coated with a thick, dirty layer of such matter. This makes the rails very greasy, so that the wheels slip very much and it remains impossible for some time to haul heavy trains. The improvements recently made in this system of firing lead to the expectation that it will contribute more towards the improvement of air conditions in tunnels in the future than it has hitherto done.

Measures which have been tried for improving the conditions under which the crews of the pushers work, include the provision of compressed-air reservoirs to supply fresh air in the cab, and of oxygen-breathing apparatus and smoke-protection helmets. Such measures, however, met with but little success or else proved very difficult to carry out in practice. On the other hand rather satisfactory results have been attained by drawing air from the bottom of the tunnel and discharging it into the cab. The device used consists of a small Laval steam turbine and rotary blower. The suction head (below the axles) has perforated plates, between which is placed a filling of wood-wool soaked in milk of lime. The vertical discharge pipe has a trumpet-shaped end just below the roof of the cab, so that the air is blown against the roof and deflected to both sides of the cab.

These arrangements do not provide an effective remedy where the track men suffer and find it difficult to attend to their work. A complete improvement of these conditions can be obtained only by the introduction of electric traction, or the installation of a ventilating plant. Electric traction is proposed for the short section between Trieste and Opcina. A ventilating plant was built for the Tauern tunnel and is proposed for the Bukovo tunnel.

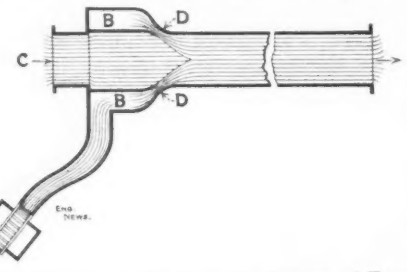

Fig. 1. Diagram of the Saccardo System of Tunnel Ventilation.

Ventilating Plant of the Tauern Tunnel.

The Tauern tunnel (5.3 miles, double-track), has an ascending grade of 1% for over three miles from the north portal, followed by descending grades of 0.33, 0.4 and 0.2%. In view of the long 1% grade and the expected rapid increase in traffic it was decided to install a ventilating plant on the Saccardo system, and to do this during the completion of the tunnel, when the work could be done more economically than after the tunnel was in service.

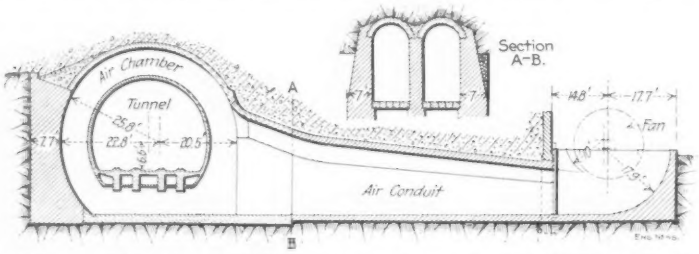

FIG. 2. SECTION SHOWING THE FANS, AIR CONDUITS AND AIR CHAMBERS FOR VENTILATING THE TAUERN TUNNEL (AUSTRIA). BY THE SACCARDO SYSTEM.

The principle of this system (described in our issue of Aug. 31, 1899) is shown in Fig. 1. Air from a fan or blower (A) is delivered to an annular chamber (B) just inside the portal (C) and from this it escapes through a ring of nozzles (D) into the tunnel. This produces a current of air, while the injector action draws in fresh air through the portal. The system can be applied either for forcing air into or exhausting it from the tunnel. The former method is used more generally, and is used at the Tauern tunnel.

In long tunnels, which (as in this case) can be ventilated only from one end, blowing in air is technically more advantageous than drawing it out. For the removal of smoke it is advisable to blow in the direction against the trains running uphill. In this case the difference of pressure existing between the air in front and behind the train, producing a natural current between the train and the sides of the tunnel, will be reinforced by the artificial current, and the smoke will be driven back quickly behind the train. These conditions necessitated locating the plant at the south end of the tunnel, at which end also there was a hydro-electric plant of sufficient power, which had been built for the construction work.

In designing the ventilating plant the two following requirements were chiefly considered: (1) to renew and dry the air in the tunnel as soon as possible after the passage of a train, in order to protect the maintenance-of-way forces; (2) to avoid the injurious effect of smoke when heavy freight trains are ascending the long 1% grade, in order to protect the men on the trains.

In the determination of the maximum power of this ventilation, mining experience and practice were taken as a basis, according to which the speed of moving air in shafts used by men (even if only occasionally) must not exceed 19 ft. 8 ins. per sec. As the Tauern tunnel has a clear cross-section of 473.63 sq. ft. this speed corresponds to an air supply of 565,000 cu. ft. per min. Investigations, however, led to the conclusion that under normal traffic conditions it will suffice if the ventilation plant produces an air current having a speed of 16 ft. 5 ins. per sec., and this corresponds to a supply of 470,770 cu. ft. per min. In order to utilize the natural current of air in the direction of the artificial ventilation and to produce a current having a speed not exceeding the velocity of 19 ft. 8 ins. per sec., the plant had to be designed to suit various intensities of traffic. It was decided to give a range of velocity from 9 ft. 10 ins. to 19 ft. 8 ins. per sec., corresponding to about 282,330 cu. ft. and 565,000 cu. ft. per min. The higher power will overcome a contrary wind of 9 ft. 10 ins. to 13 ft. per sec., but natural currents of such strength will occur seldom and for a short time only. During such times the ventilators are stopped and the tunnel is left to natural ventilation.

After the output of the ventilators had been settled, the next question to be considered was whether the quantity of air required should be supplied by one or several blowers. The decisive factor is the pressure required. The quantities of air required for the ventilation are not materially different for short and for long tunnels. In the former case, however, much less pressure is necessary. In order to ventilate smaller tunnels, it is advisable (taking the capital outlay into consideration) to use two smaller blowers working in parallel, as otherwise it would be necessary to use a very large blower running very slowly. Should one blower break down, the installation can still work at half power. In tunnels having a length exceeding 2.5 miles, working in parallel is no longer suitable. The ratio of quantity of air to pressure is then such that the use of one blower of suitable dimensions must be considered the best solution. It is true that in the case of the Tauern tunnel two blowers were installed; but only one will be used to do the work, while the other is held as a reserve.

In order that the blower may give an output corresponding to the limits specified above, a power of 220 to 1,100 HP. is required at the shaft. The large blowers are on the Capell system. Each blower draws in air from both sides and the fan has a diameter of 18 ft. and a width of 6 ft. 6¾ ins. The aspirating towers on both sides of the fan casing extend to a height of 45 ft. 6 ins. above the axis of the fan, and the inlets have a cross-section of 47.47 sq. ft. each. Owing to the difficult snow conditions which obtain in winter, it was necessary to protect the four inlets of the aspirating towers by a special roof, placed above the main roof, fitted with louvers on all sides.

Alternating current at 5,500 volts was available at the power station, 3¼ miles distant. As the speed of the fan is required to be adjustable between 100 and 200 r.p.m. this current is transformed to low-tension direct current for the motors which are directly connected to the fan shaft.

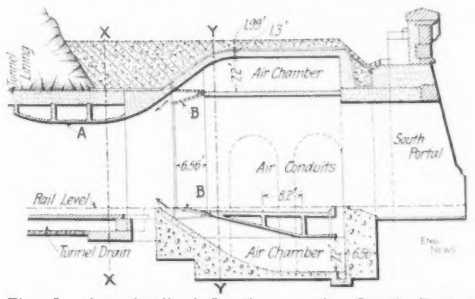

Fig. 3. Longitudinal Section at the South End of the Tauern Tunnel, with the Air Chamber for the Ventilating System.

The air from the blowing fans is delivered to the annular air chamber at the tunnel through two conduits (one from each fan). Sections of these conduits and chamber are shown in Figs. 2, 3 and 4. Formerly, it had been the usual practice to construct the air chamber of sheet iron, but this is subject to corrosion; the chambers also have had many corners, projections and stays, which form a resistance to the air and thus cause loss of pressure and reduction in efficiency of the air jets. At the Tauern tunnel, the chamber and conduits are of reinforced concrete, with no obstructions in the passage, and the surfaces are given a smooth coat of cement. The wrought iron nozzle has 17 chambers and orifices, three of which are below the rail level. The upper parts of these orifices are made movable, as shown at (A) in Fig. 3, so that the cross section can be varied. This arrangement makes it possible to determine by experiment the best

*Abstract of a report on the Construction, Ventilation and Operation of Long Tunnels, presented at the International Railway Congress, at Berne, Switzerland, in 1910. Published in the November number of the "Bulletin" of the Congress.

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form to be given to the escaping annular stream of air, and to adjust the orifices for the greatest efficiency. To guide the air current more effectively, the cross section of the tunnel is reduced by a false roof of concrete, as at (B) in Figs. 3 and 4.

The total cost of the plant was about $176,800, this high cost being due to the duplicate equipment for reserve and to some difficulties in the construction. There is a full equipment of apparatus for measuring the flow and velocity of the air, and for analyzing samples of the tunnel air. The operating expenses (with two shifts of attendants) are estimated at $5,400 to $6,000 per year under present conditions, and $6,900 to $7,350 per year when the heavy traffic conditions are realized. No figures are given as to the number of trains.

General Conditions.

The power required, measured at the shaft of the blower amounts to 220 to 680 HP. under normal conditions and to 1,100 HP. as a maximum. The Saccardo ventilating plant at the St. Gothard tunnel* requires 700 to 800 HP.; that at the Kaiser-Wilhelm tunnel (13,780 ft.), 220 to 250 HP., and 120 HP. at each of the two smaller steep tunnels in Upper Italy, the Pracchia tunnel (8,973 ft.) and the Piteccio tunnel (5,817 ft.).

These figures show that the Saccardo system of ventilation has two material defects: great quantity of power required, and low efficiency. Nevertheless this system is at present the best existing method for ventilating mountain tunnels and has received a number of applications in different countries during the last few years.

A material improvement could be introduced if by a suitable arrangement of the air chamber, orifices and air conduits, the installation at one end of the tunnel could be made both to blow in air and to draw it out. This would require double orifices for blowing and for exhausting. It could be worked either with two fans (one for blowing and the other for exhausting), or with one fan which could be made to blow or exhaust by suitable design of the air conduits, and by their regulation. The advantage of such an arrangement would be that any natural current in the tunnel could be utilized for ventilation. As compared with the present single-acting Saccardo system this would increase the efficiency by 10 or 15%, and reduce the power required by 40 to 45%. The most economic method of tunnel ventilation consists in the use of a ventilating heading. Where the bottom-heading method of construction is adopted, the simplest method of ventilation will be (as Dr. Hennings also observes†) to use the lower heading for conveying air. To obtain good ventilation in this way it would be advisable to have at a few places in the tunnel branches from the ventilating heading (or conduit) forming annular conduits around the tunnel, from which the air would be blown in a manner similar to that of the Saccardo system.

In estimating the economy of a ventilating plant, it must not be forgotten that although the main object is to benefit the trainmen and trackmen, it also contributes very materially to the better preservation of the track. In long, badly-ventilated tunnels the track becomes worn very quickly and maintenance is consequently expensive. For instance, it was necessary to renew the track in the Kaiser-Wilhelm tunnel (Germany) three times in 20 years. The chief reason of this quick destruction is that the sulphurous acid contained in the smoke of the locomotives becomes oxidized to sulphuric acid which becomes deposited on the rails and causes them to rust very quickly. In addition, if the smoke is not properly removed, substances produced by the combustion of the coal (or oil, in the case of the Arlberg tunnel, with still more unfavorable results) become deposited on the rails, and the track thus becomes coated with a greasy, slimy layer. In consequence of the want of adhesion, the rails are then subjected to the abnormal dynamic action of the engines. With this frequent hammering action rail fractures are frequent. On the other hand the dampness of the tunnel and the strong braking required on the locomotives, with sanding, result in much wear of the rails.

In the Arlberg tunnel, the rail wear in ten years amounted to 5/8-in. at wet spots, 7/16-in. at damp spots and 11/32-in. at dry spots. In spite of this, no rail fractures occurred at the wet spots. This is explained by the fact that the slimy layer is washed from the rails by the water which is continually dripping upon them, so that there is an absence of the lack of adhesion which results in the hammering action.

Sufficiently powerful artificial ventilation therefore removes the chief causes of the rapid track destruction. This is not only better for the track, but also reduces the rate of decay of the tunnel lining. Experience leads to the conclusion that proper ventilation of the tunnel materially increases the length of life of the track, in some cases even doubles it. As the cost of completely renewing the track in a long tunnel is very high, this favorable influence of artificial ventilation represents a great saving in maintenance. Consequently if the large power required for such a plant can be supplied by a cheap water-power, the introduction of such artificial ventilation also reduces the cost of upkeep of the track. In addition there is also increased safety for the traffic: rail fractures are avoided, the reliability of audible and visible signals is increased, and injurious effects upon the trainmen and trackmen are eliminated.

Conclusions.

(1) VENTILATION DURING CONSTRUCTION.—For tunnels having a length of 2½ to 6 miles it is advisable to send in air through conduits, and on each side from 5,300 to 12,360 cu. ft. per min. are required. The blowers must be arranged in series. The conduits must be kept as free from leakage as possible, with a view to good efficiency and small consumption of power. They must have a clear diameter of at least 23⅝ ins. in the working section and 15¾ ins. in the bottom (advance) heading.

(2) VENTILATION DURING OPERATION.—The unfavorable state of the air in badly-ventilated tunnels can be modified by the suitable firing of the locomotives. The use of small fans, mounted on the locomotives, drawing purified (filtered and neutralized) air from the bottom of the tunnel, reduces very materially the amount of inconvenience which the locomotive crews suffer from the smoke.

Artificial ventilation by the Saccardo system, in spite of its low efficiency and the large amount of power required, is at present the most useful ventilation system for mountain tunnels. It is advisable to modify this system in the case of long tunnels so as to have a double installation at one end of the tunnel, able both to blow air in and to draw it out. This increases the efficiency and reduces the amount of power required. The use of a separate ventilation heading (bottom heading) gives the most economic method of ventilation. Artificial ventilation increases the safety of the traffic in the tunnel and materially contributes to the better preservation of the track in the tunnel.

It would be advisable to ascertain in detail the conditions which led to the introduction of artificial ventilation in the case of tunnels where electric traction is used (dampness in the tunnel and its influence on the electrical installation on the locomotives).

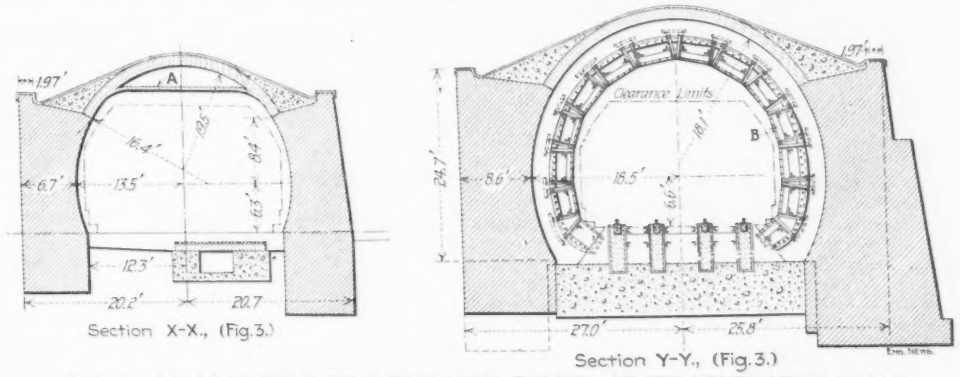

FIG. 4. CROSS-SECTION OF THE TAUERN TUNNEL AT ITS VENTILATING PLANT.

*In another paper presented at the International Railway Congress by Prof. F. Hennings, of the Zurich Polytechnic School (Zurich, Switzerland), it is stated that the system at the St. Gothard tunnel differs from the Saccardo system in having the portals fitted with canvas doors which are opened (by the signalman) only to let trains pass in and out.—Ed.

†The paper by Dr. Hennings (in the February number of the "Bulletin" of the International Railway Congress) deals with tunnel ventilation only incidentally. He says that where an under heading and electric traction are used it will be possible to ventilate by the ventilating system used during construction. This can be done by putting a door (which can be closed) in the middle of the heading (presumably this refers to a conduit beneath the track) and then blowing in at each end about 1,766 cu. ft. of air per sec. Curtains in this conduit and adjustable openings in its cover plates will make it possible to lead the air into the tunnel as desired. Mr. Heine proposes to supplement this by occasional annular chambers connecting with the conduit.—Ed.

Bituminous Compounds in Macadam and Earth Road Construction.*

By T. R. AGG.†

The Illinois Highway Commission has made considerable use of bituminous compounds in road construction during the seasons of 1908, 1909 and 1910. The form of construction involving the use of these compounds was looked upon as entirely experimental and although there has been considerable progress made towards standardizing these materials and the methods of construction involving their use, still the use of tars and asphaltic compounds for construction purposes must be considered as more or less experimental.

The roads that were built by the Commission were constructed for the purpose of determining the following: (1) The general desirability of the poured asphalt or tar-macadam road as regards dustlessness resistance to wear and comfort of travel; (2) the relative cost of the waterbound macadam and the tar or asphalt poured macadam; (3) the relative cost of maintenance of waterbound macadam and the poured asphalt or tar macadam; (4) the suitability of an asphalt oil in the construction of earth roads.

Bituminous Macadam Roads.

In this construction it was decided to confine the experiments to the poured macadam. It is a matter of common observation that on roads which are traveled exclusively or almost exclusively by farm teams, the traffic confines itself to a width of 7 or 8 ft., the wheel wear coming entirely upon two strips of the roadway which usually do not exceed 2 ft. in combined width. Then there is a marked tendency for bituminous macadam to squeeze out along the wheel track, forming a broad depression. The wear also must necessarily be great where the vehicles all follow the same track. This depression will eventually become deep enough to hold water, which hastens the deterioration of the road. On village streets there is no such tendency, as the traffic must necessarily spread out because of the constant passing.

Where the above conditions are encountered, it is essential to so design a poured macadam pavement that the lower course shall give stability and the upper course provide a durable wearing surface so placed that the opportunity for lateral displacement of the stone composing it is reduced to a minimum.

Four sizes of stone are used in the experimental bituminous roads as follows: (1) 3-in. stone (passing over a 2-in. and through a 3-in. screen); (2) 2-in. stone (passing over a ¾-in. and through a 2-in. screen); (3) chips (passing over a ¼-in. and through a ⅝-in. screen; (4) screenings that pass through a ¼-in. screen, sometimes containing a percentage of chips.

In general, bituminous macadam roads have been made about 9 ins. thick at the crown and 6 ins. at the edge, after rolling. The stone is placed in two courses. The top course of 3-in. stone is 2½ to 3 ins. thick after rolling, and the lower course of 2-in. stone is 6½ ins. thick at the crown and 3½ ins. at the shoulder or curb line, after rolling. The lower course is spread, harrowed, rolled and bonded with water and screenings in the manner of an ordinary waterbound macadam roadway.

It was learned early in the experiment that an essential part of this form of construction is to have the top course of uniform texture, and it was found that herein lay the greatest difficulty in the construction. Unless every detail is carefully watched, it is certain that there will be a lack of uniformity in this upper or wearing course. The lower course must be laid very carefully and finished absolutely true to cross section and grade. The top course of stone must then be spread with great care so as to insure uniform thickness, it must be harrowed to bring a uniform sized stone to the surface and then rolled until it is well keyed together.

Where the 3-in. stone is used, it has usually been found necessary to sprinkle over the surface (after the first rolling) a small quantity of 2-in. stone, and to roll this smaller size into the surface. This has the effect of pushing together the larger stones in the surface and keying them tight so that after this rolling has been done, the surface presented is so compactly knit together that without the addition of any binder it is possible to haul a loaded wagon over the surface with but slight disturbance to the stone. This condition is the ideal for a poured macadam. The upper course now presents a surface which is sufficiently stable to carry the weight of the loads, and it only remains necessary to add to it something that will prevent the displacement of the stone.

It is estimated that this surface layer of stone will contain about 20% of voids after the rolling. Theoretically all of these voids should be filled to prevent any displacement of the stone, which would require a little more than 2½ gals. per sq. yd. of surface for a layer 2½ ins. thick. Practically, however, this may not be essential because the stones composing the surface have been so locked together that there is no opportunity for lateral

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movement unless some of them are removed from the surface. It is the function of the bituminous compound to prevent that, and on the state experimental roads, 2 gals. per sq. yd. has been the usual treatment. It will often be found that the surface of the road is so open that a smooth surface cannot be obtained without first filling the surface interstices. The chips are used for this purpose, being whipped into the interstices from the shovel. The surface is then broomed to sweep all chips into the voids, leaving a clean surface. The voids are then poured practically full of the asphalt or tar binder.

In the use of bituminous compounds for this purpose, two facts must be taken into consideration: (1) the material must be appropriate to the conditions under which it will be applied; (2) the application must be so made as to insure that the material will go on the surface in a uniform layer and that the surface will be in such condition as to permit the material to flow into the interstices and to fill practically all of the voids in the upper layer of stone.

Where a tar is used as a binder, the following method of application has been found very successful. The binder is received in tank cars and is heated by means of the steam coils in the cars. It is necessary that an ample supply of steam be provided and usually it has been secured from some power plant of large capacity. It is possible to heat the material in the tank car by this means to 250° F., which is sufficient to make the tars used soft enough for their application. The temperature at which the material is applied is of great importance, and the temperature which would be correct for one material will not be correct for another. The ideal condition to be reached is that the material shall be sufficiently fluid when it reaches the road to flow into the interstices before cooling. It must not remain as a mat on the top of the stone.

The tar is forced out of the tank car into a distributing wagon by means of steam pressure. This has not been altogether satisfactory on account of the water which condenses and remains in the car. If air pressure can be furnished from a portable compressor this is preferable.

The distributing wagon is then hauled to the road and attached to a steam roller. Steam connection being made from the boiler to the top of the wagon, the tar is forced out through a hose and nozzle and is sprayed onto the stone. With this method of distributing, it is possible to apply either large or small quantities of the material in a very uniform layer to the stone. The only objectionable feature is the slight amount of water which condenses in the wagon. This water turns into steam as soon as the new batch of hot binder is turned into the wagon and may cause the binder to foam.

The same general method of application has not been found satisfactory with petroleum residuum compounds because it is impossible to heat the binder sufficiently by the steam coil to make it flow through a hose. It cannot even be heated sufficiently to spread by means of hand spreading cans filled from the tank wagon. At the temperature to which it can be heated by steam the material is not sufficiently fluid to flow into the interstices of the stone. The result is that there are patches on the surface of the road which are unsightly and make the surface uneven to an extent which is perceptible to those who traverse it.

In general it is thought that asphaltic compounds should be applied to the road surface at a temperature not less than 400° F., and in some cases the temperature would need to be considerably higher, but it must not be heated to the flash point if an open kettle is used.

In using an asphaltic compound, the best results have been obtained when the material is heated in kettles, drawn off into hand sprinkling cans, and poured onto the surface layer of stone.

The first spreading of these compounds will leave the surface of the road slightly rough where individual stones project partly from the surface, owing to the fact that they have been disturbed by the men walking over the surface in spreading the chips and compound. By rolling this surface with a wet roller before a second spreading of asphalt is applied, this fault can be corrected. After the first spreading of bituminous compound, the surface of the road should be rolled and then covered with stone chips, and thoroughly broomed so that these chips work into all of the interstices and voids. This is the most important operation aside from the pouring of the compound, but if it is carefully done an extremely uniform surface can be secured.

After this, a second spreading of compound (in the nature of a paint coat) is applied to the surface. This should not exceed ½-gal. per sq. yd. In the first application the amount of compound must be determined by the nature of the surface layer of stone. Usually 1¼ to 1¾ gals. per sq. yd. has been used in our work.

Character of Tar Used.

Experience with the use of various bituminous compounds led to the conclusion that there are some important variations in the characteristics of the commercial preparations. In the absence of accepted standard specifications for these compounds, no attempt was made to secure compounds meeting any certain specification except in a few instances, but all materials used in 1909 and 1910 were analyzed according to approved methods and a record made of the results (see accompanying table). It is thought that a study of these analyses and a comparison of them with the behavior of the compounds on the roads will give information that may eventually be incorporated in a set of specifications. Inspections were made in 1910 of roads built in 1909, and the condition of the various tars is summarized as follows:

(A).—This gave fair results as a binder, holding the surface of the road intact and forming a slight mat on the surface which plainly showed the prints of horse shoes. During hot weather the material softened sufficiently to flow out of the macadam on to the earth shoulder at the edge to some extent. The constant kneading of the mat surface seemed to deaden the material so that it began in places to separate from the stone and to become brittle. So far the wear is almost entirely on the mat of tar on the surface of the macadam.

(B).—The same general conditions were found as where (A) was used, except to a slightly less degree, with the probability that the life of (B) will be somewhat longer.

(C).—This seemed to work out on the surface to an undesirable extent and became quite soft during hot weather, running onto the earth shoulders in large quantities. The mat on the surface is dead and brittle and is peeling off from the stone. This seems to be the poorest tar used during the season. So far the mat of tar is taking all the wear.

(D).—This tar was used on a road so situated that large quantities of mud were carried onto it during the winter. The tar appears to be dead and somewhat brittle, and does not seem to have held the chips in the interstices of the upper layer of stone. The surface of the road is rough, the wear all coming on the stone.

(E).—This has held its life well on a very heavily traveled road. On about 60% of the surface, the tar has worn off entirely, the surface presenting a mosaic appearance, each stone being surrounded by the tar, the stone forming the wearing surface. On the remainder of the surface, the tar forms a thin mat, taking the wear and protecting the stone. This tar is apparently the best used during the season.

(F).—This was used in resurfacing work where a considerable quantity of stone dust and mud was found on the road. The tar became brittle and wore off the surface. There has been no loosening of the stone. It is thought that the poor results here were due in part to the fact that the tar was applied in cold weather.

(G).—About the same results were obtained with this material as with (D), under similar conditions.

(H).—This was used under conditions similar to those for (D) and (G). The results were better, however, the surface being fairly smooth. The chips held in place in the interstices of the surface. The stone is taking the wear and the surface presents a mosaic appearance.

(J and K).—With these materials the stone is held in place but the wear is on the stone. The tars become slightly brittle during cold weather, but in warm weather seem to regain their life. They did not soften enough to flow.

(L).—This tar became brittle. The surface of the road cracked under traffic, due to the fact that the tar was applied during cold weather, and that the road was not in proper condition for receiving the tar treatment.

In general, it may be said that all the roads were dusty except those that had an excessive mat of tar on the surface, and these were comparatively free from dust. This mat, however, is probably short lived and the conclusion is that all tar-treated roads will become dusty within two or three years after construction, and that if the mat surface is not obtained, the roads will be dusty from completion. The surface layer of stone, in all cases, is held firmly in place; but the finer particles in the interstices are not held in place by brittle tars.

It is probable that when the mat surface wears off it can be replaced by applying a proper grade of tar in the nature of a paint coat, and that this will be the cheapest method of maintaining roads of this character.

It seems that some change must be made in the character of the tars available for construction purposes, to insure that they will not soften and flow in hot weather and not get brittle during cold weather. Just how this can be done is not at once apparent, but it is probable that the volatile light oils should be eliminated and the free carbon held as low as possible. There should then be a sufficient quantity of dead oils present to give elasticity to the pitch.

Oiled Earth Roads.

The oiled earth construction was undertaken with the object of determining its durability under the soil and climatic conditions of Illinois. It was desired to accomplish something more than a surface treatment which would merely serve to alleviate the present dusty condition of roads during dry weather, and possibly reduce the cost of maintenance on a country road. It was therefore necessary to incorporate into the surface layer of earth on the road a sufficient quantity of an asphaltic oil to render this surface layer impervious to water.

In accomplishing the above purpose, it seems possible that such a large quantity of oil will need to be used that in hot weather the oil will soften sufficiently to make the surface of the road plastic. In this case, the concentrated traffic during the summer will squeeze out the surface of the road along each wheel track, forming a rut and leaving a slight ridge outside of the wheel track. Then the slight depression formed by the wheels will hold water and will soften and eventually cut through.

But it seems probable that if the surface becomes sufficiently plastic to be put out of shape, it will also be sufficiently plastic to be readily put back into condition. Therefore it is probable that on such a road the surface can be reshaped about once a year. If this is done the road will not get muddy to any extent during the winter. It is possible then that the road may be well worth its cost, but until we have more experience no definite answer can be made on that point.

EXPERIMENTAL ROAD (Ivesdale Road, Bement Township, Piatt County).—This oiled earth road was constructed in 1908 on a black gumbo soil by using an asphaltic oil in such amount as to give a layer about 5 ins. thick, treated with as much oil as it would absorb. The center of the road for a width of about 15 ft. was plowed, disk-harrowed and pulverized. The pulverized earth was then moved to the side of the road and the middle portion or roadbed, on which the oil was to be used, was shaped and thoroughly compacted with a 10-ton steam roller. Alternate layers of oil and earth were then placed on this foundation, thoroughly mixed with a disk harrow, and rolled. The road was finished by putting on a light layer of earth and rolling the surface.

Numerous difficulties were encountered, particularly in getting proper mixtures of the earth and oil. This mixture when once made was of such a gummy nature that it was almost impossible to get it evenly distributed over the surface of the road. Also the nature of the soil was such that it could not be entirely reduced to dust and there were numerous large clods in the mixture which were not broken and remained in the surface of the road after its completion. It was found that the oil never impregnated these larger pieces of earth.

Subsequent work on this road showed that the earth and oil mix more uniformly if the earth is moistened with water during the mixing process. At first the road is very soft, but as the water dries out the surface becomes harder. During this time the road should be rolled and kept smooth.

Conclusions.

The experiments have shown conclusively that a poured macadam is a desirable roadway. It has an elastic surface pleasant to travel and much less dusty than the untreated macadam. While the roads built have not been in service long enough to give accurate data as to life, it is apparent that for some years the wear will be entirely on the bituminous compound, if a proper one is used. In general we may safely state that the life of the road is greatly lengthened, especially if the road has a mixed traffic with a considerable proportion of one-horse vehicles and automobiles.

Oiled-earth construction must be considered as of doubtful value, so far as the experiments already made may be interpreted. While there can be no question but that the roads were greatly benefited, it remains to be proved that the treatment is worth its cost of 30 cts. per sq. yd.

As to the relative cost of the waterbound and bituminous macadam, the tar-macadam will cost 15 cts. per sq. yd. more than the waterbound (at the present cost of tar); the asphalt-macadam will cost from 15 to 20 cts. per sq. yd. more than the waterbound, depending upon the price paid for asphalt.

In regard to the relative cost of maintenance, no data can be given because none of the bituminous roads have been in service long enough to determine this point. It seems probable, however, that a bituminous macadam will maintain its surface at least as long as a waterbound macadam and probably much longer. When necessary it can be repaired by a surface dressing or paint coat of the proper grade of binder at a cost of about 15 cts. per sq. yd. To properly resurface a waterbound macadam road would cost 30 cts. per sq. yd.

PROPERTIES OF TARS USED FOR ROAD TREATMENT; ILLINOIS HIGHWAY COMMISSION.

	Where used.	"Dow" penetration 5° C. 50 gms.	Specific gravity.	Free carbon, P. ct.	Results of Distillation. First light oils, P. ct.	2nd Light Oils. Amount, P. ct.	2nd Light Oils. Solids, P. ct.	Dead Oils. Amount, P. ct.	Dead Oils. Solids, P. ct.	Pitch residue.
A	East St. Louis	22.6	1.230	24.99	1.76X	4.64	25Z	32.72	75	60.88
B	Edwardsville	17	1.240	22.30	1.20X	4.40	60Z	22.12	70	72.28
C	East St. Louis	*	1.222	21.03	0.66X	6.70	90Z	24.00	35	68.64
D	Bushnell	23	1.236	19.54	1.33Y	0.66	....	26.67	60	71.34
E	East St. Louis	11	1.243	20.68	2.67Y	....	....	20.00	25	77.33
F	Elburn	12	1.240	20.18	1.33	....	....	30.67	50	68.00
G	Mt. Sterling	19	1.243	18.55	....	5.33	100Z	28.67	90	66.00
H	Bushnell	14	1.219	18.27	4.00Y	....	....	24.67	3	71.33
J	Flossmoor	10	1.255	22.13	0.67X	2.67	100Z	21.33	80	75.33
K	Flossmoor	19	1.238	22.09	....	6.67	100Z	21.33	90	72.00
L	Grant Park	33	1.239	22.24	....	....	....	24.67	40	75.33

X: Ammoniacal water present. Y: Non-ammoniacal water present. Z: Solids principally naphthalene.
*Too soft to test.

Washing Dust and Smoke from Chimney Gases at York, England.

By JOHN B. C. KERSHAW.*

At the York, England, meeting of the British Association for the Advancement of Science, held in August, 1906, Messrs. S. H. Davies and F. G. Fryer, the chief Chemist and Engineer of Messrs. Rowntree's Cocoa Works, read a paper describing a novel form of smoke-washing apparatus, in use at those works for the removal of dust and smoke from the chimney gases. As increasing attention is now being given in all countries to the subject of smoke prevention, and as this smoke-washing apparatus with some important modifications is still in operation at Messrs. Rowntree's York Works, the author has thought that the following notes upon it would prove of interest to readers of Engineering News. The description of the apparatus is given largely in the words of the original paper by Messrs. Davies and Fryer.

The boiler installation at Messrs. Rowntree's works consisted of six Lancashire boilers, 30 ft. by 96 ins. and 102 ins., working at 100 lbs. pressure, and fitted with Bennis sprinkling stokers and with coal-feeding elevators. Economizers and superheaters were employed and the average consumption of fuel amounted to 310 tons per week.

An induced-draft installation was added in 1904, in order to increase the capacity of the plant and to cope with the increased demand for steam without adding more boilers. The fan was of 7-ft. diameter and was placed at the base of the brick chimney, which was 6 ft. in diameter and 150 ft. in height. With this fan and chimney the draft at the main flue was about ¼-in. of water with all the boilers in use, or about double what was obtained with chimney draft alone.

The only class of coal which could be obtained at an economical rate was a dusty pea slack from the South Yorkshire coalfields, having an average calorific value of 12,500 B. T. U. and containing 10% of ash. Of this coal, 40% consisted of dust and fine smudge which passed through a 3/16-in. mesh. The average evaporation under usual working conditions in each of the smaller boilers was 975 gals., and in the larger boiler 1,120 gals. per hour, from and at 212° F. This high evaporation could only be secured by the combustion of approximately 32 lbs. of coal per square foot of grate area. It represented 8.5 lbs. of water per pound of coal, or, if due allowance be made for the work done on the superheaters, 9.06 lbs. of water per pound of coal from and at 212° F., and this with low-grade coal of 12,500 B. T. U.

Working under these conditions, every effort had been made to reduce the amount of smoke generated, and for some time prior to 1906 no black smoke in its technical significance had been emitted. The special desire for a model factory, however, with entire freedom from dust, led the directorate to demand much more than this, and they determined to secure a smokeless exit from the chimney. With induced draft and a dusty fuel, the problem resolved itself mainly into the removal of dust and grit, the relatively small amount of carbonaceous smoke being of secondary importance. With the sort of coal used, it was impossible to ensure such a result with any of the known smoke-curing appliances. Coking stokers, for instance, were not specially suited to this class of fuel and would not give the required evaporation. Moreover, they provide only a partial remedy for dust. Coal-dust firing involved the provision of costly grinding mills and a heavy charge for power. Under these special conditions, the engineers could not aim at what may prove to be the ultimate solution of the problem—the non-production of either dust or smoke in the furnace—so they turned to the only alternative, that of intercepting the dust and smoke from the furnace gases.

To do this they arranged the flues so that the gases could travel in either direction through the economizers, and built a brick chamber (37 ft. long, 14 ft. 6 ins. wide and 17 ft. high) at the end opposite the existing fan and chimney, in which chamber the gases could be washed. This chamber is subsequently referred to as the "smoke-washer"; its details are shown in the accompanying diagram. The gases were drawn through the smoke-washer by an 8-ft. 6-in. steam-driven, induced-draft fan and were delivered to a steel chimney of 7-ft. diameter rising 50 ft. above the top of the washer. The fan was run at a sufficient speed to give about ½-in. draft by water-gage in the main flue.

The smoke-washer was lined with Staffordshire bricks, set in cement; the four baffles were made of cast-iron plates. Water was supplied in the form of coarse spray through a number of Harrison's patent spraying nozzles (numbered 1 — 7 in the diagram) and further in the form of continuous sheets of falling water (A, B and C). There were also two hot and one cold-water nozzles (N) close to the inlet from the flues. The floor of the smoke-washer sloped towards the outlet, and any grit or dust deposited in it was washed down at intervals by a flush of water from three automatic tippers (T) built into the walls. After passing a water seal, the grit was collected in either of two parallel settling tanks.

At first a portion of the wash water was recirculated through the plant, but the acidity increased so rapidly that this plan was abandoned. Neutralization of the circulating water with milk of lime proved too costly. A sufficient supply of fresh water drawn from a well and involving only the cost of pumping was therefore employed. This reduced the acidity to a mere trace, and the wash-water was run off into drains.

The gases passed from the economizer chamber at a temperature of about 320° F. and at a velocity of 20 ft. per second into the first section of the smoke-washer (a space 14 ft. 6 ins. long by 11 ft. wide by 16 ft. high) where the velocity was reduced to 3.7 ft. per second. It was found best to saturate the gases as far as possible with water vapor in this section, supplying a plentiful spray of hot water from the economizers through nozzles (shown at N) at a temperature of 250° F.; to which is added exhaust steam from the fan engine. After passing over the first baffle, the gases came in contact with cold water from one or both of two sets of sprays (3 and 4) in the second section. They impinged against wet walls and swept down on to a floor covered with running water, before passing under the second baffle. At this point, when necessary, they could be drawn through a continuous sheet of water (B) falling from the edge of the baffle. In the third section, the gases were subjected to further chilling and washing by means of cold water sprays (5 on the diagram), and if desired, the process could be repeated in the fourth section, by sprays (6). The gas emerging under the last baffle could be washed by another sheet of water (C) and passed direct into the fan suction from the last section of the chamber, which contained a single nozzle (7).

It will be seen that the first section of the smoke-washer constituted a resting and saturating chamber in which the velocity of the gas was greatly diminished and in which a large amount of water vapor was taken up. Here most of the heavy grit was deposited. The gas was then chilled and washed in the succeeding sections, causing the deposition of the lighter fume and smoke. This deposition was greatly assisted by the condensation of part of the water vapor taken up in the first section. The areas were kept large throughout, enabling the gas to travel at a comparatively slow pace and not increase the work of the fan. Any arrangement for forcing the gas through restricted areas or bubbling it through water was avoided. Splashers or other mechanically-operated devices were also avoided, and great importance was attached to simplicity of design.

Experimental Results.

Experiments were carried out with this smoke-washer to determine at what point a limited amount of water could be best applied, and the following conclusions were arrived at:

1. The application of steam and hot water in the first section gives much better results than the use of cold water sprays at this point.

2. The cold water is best applied in the second and third sections, e. g., sprays 3 and 5.

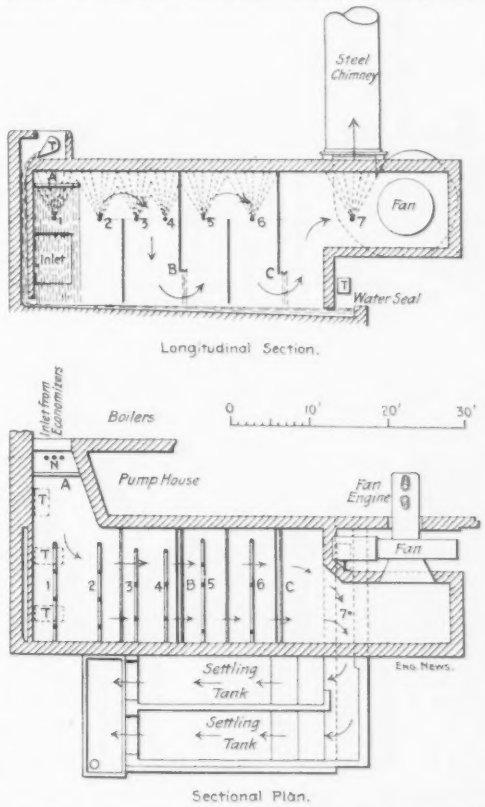
3. The application of sheets is an extravagant method of using water, and so long as the walls and floor are kept wet and the sprays are under sufficient pressure, sheets of water may be dispensed with.

4. With gases leaving the economizer at 300° to 350° F. a favorable temperature for the exit gases is 130° to 135° F., while the water running to waste has a temperature of 110° to 115° F.

5. The minimum volume of water requisite to deal with 2,400,000 cu. ft. of hot gases per hour, is from 7,000 to 8,000 gals., distributed approximately as follows:

Cold water	tippers	1,000 gals.
	sprays	5,000 "
Hot water sprays		1,300 "
Exhaust steam		100 "
Total supplied		7,400 gals.
Less water vapor required to saturate exit gases at 130° F.		1,000
Water running through settling tanks to waste		6,400 gals. per hour

A comparative set of experiments upon the washed and unwashed gases showed that the whole of the grit and dust and practically the whole of the smoke and the sulphur acids were removed in the smoke-washer. The amount of grit collected was about 1,600 lbs. per 24 hours (calculated on the dry material) equivalent to 1.5% of the coal burned. The grit was of a light porous nature and contained on an average 60% of combustible matter.



Smoke Washer for Chimney Gases at Rowntree's Cocoa Works, Troy, England.

(Drawn as originally designed. It was subsequently found necessary to change the location of the fan and replace the steel chimney by one of wood, to avoid trouble from sulphuric acid.)

Although the smoke-washer was a somewhat expensive plant to erect, and the cost of running was considerable, the designers believed that it would prove much the most economical device that they could adopt to secure the very special conditions demanded at Messrs. Rowntree's factory. Allowing ample capital charges and working costs, they estimated that it would add 10% to the annual cost of coal. In this connection, it may be noted that if they had made use of coal screened from dust, it would have involved an additional cost of 50% on the coal bill, and even this would not in itself have ensured

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complete freedom from grit nor have solved the smoke difficulty. Moreover, their tests had already shown that the larger coal did not give any better evaporative results. Similar smoke-washers might be adopted with great benefit to the neighborhood by many large factories and generating stations, and could be run at a moderate expenditure wherever a cheap and plentiful supply of water is available.

Modifications in Design.

Four and one-half years have now elapsed since this smoke and dust washing plant was started at Messrs. Rowntree's Works in York, and those who saw the apparatus with the writer in August, 1906, and condemned it as costly and impracticable, will be surprised to hear that it is still in use with certain modifications.

The induced-draft fan, as well as the steel chimney, were found to be seriously affected by the sulphuric acid which condensed upon their surfaces, and the fan was therefore removed to the opposite end of the chamber. The gases are now discharged vertically downwards at the inlet end of the chamber, and immediately upon entering they are moistened by water at a temperature of about 230° F. supplied through two spraying nozzles, this water being heated by an extra battery of economizer pipes. Practically all this water is taken up by the gases in the form of vapor, and the first portion of the chamber therefore serves as a saturating chamber. The gases being discharged downwards, the heavier particles of grit fall by their own weight onto the chamber floor, and never come up again; many lighter particles that would not fall by their own weight do so after becoming saturated.

The installation, as originally designed, worked well as far as the grit was concerned, but was not so successful as was desirable in the subsidiary object of removing smoke. Further alterations were made to improve its performance in this respect. About the center of the chamber, a wooden "scrubbing" arrangement was placed, formed by 1¼-in. wooden laths. The scrubber is 2 ft. thick, and is fixed at an angle of 45°. This is kept well sprayed with cold water. The majority of the lighter particles suspended in the gases, and even much actual smoke (when such occurs), is "scrubbed" out and condensed at this point. The gases pass from the chamber by a wooden chimney similar to that used for cooling towers. Although about 80% of the SO_2 is actually washed out the remaining 20% is carried forward in the form of sulphuric acid, and it was this which had attacked the original steel chimney.

The grit is separated from the water in settling tanks as described in the original paper, and is carted to the dump, as no use for it has yet been found. About 24 tons (calculated on the dry grit) are collected per week. The percentage of carbon in this is not high, and it is very difficult to obtain combustion of this carbon even in laboratory experiments.

Although this smoke-washer has been in operation now for over four years, the chemist and engineer of the works state that they have not come across any alternative which would be more successful or more economical than this. The Rowntree company has patented the apparatus merely to safeguard themselves, but the directors, who are interested in the question of the prevention of smoke and tar, wish free use to be made of the idea by anyone interested, and desire to give any assistance in their power with regard to this matter. The writer's thanks are due to Messrs. Davies, Fryer and McLellan of Messrs. Rowntree's Works, for the information given in this article and for the plan and elevation of the smoke-washer as originally designed.

REFRACTORY CEMENTS to replace fire clay as a bonding material for furnace bricks are being placed on the market by the H. W. Johns-Manville Co., 100 William St., New York City. The new cements are rated to resist temperatures as high as 3,000° F. They are intended for use in furnace, crucible and cupola settings and linings, and for patching and facing bricks while in place in the fire zone. A coating for firebrick walls, known as "brickline" cement, is claimed to prevent the adherence of clinkers.

Reinforced-Concrete Electric-Lamp Poles for St. Marys Falls Canal, Michigan.

By L. C. SABIN,* M. Am. Soc. C. E.

The improvements in progress at St. Marys Falls Canal have made such changes in the canal walls as to necessitate replacing several electric light poles and adding others, and the improvements contemplated will call for many more changes of this kind. The electric-lamp poles in use were made of timber, 11½ in. square at the bottom and 8 in. at the top, with chamfered corners, and surmounted by a standard holding the light erect above the pole. These poles have to be renewed quite frequently because of decay just above the ground surface, and the increasing cost of timber makes such renewal expensive. It is proposed to place all wires underground as fast as the proper conduits can be laid in connection with other work, and a lamp on a wooden pole is not easily connected with underground wires.

For these reasons it was decided to build an experimental pole of concrete to test the adaptability of the material and determine the cost, and this experiment proved so satisfactory as to warrant the construction of 40 poles of the same general type.

The requirements to be met were that the lamp should be 30 ft. above the ground, that the wires should lead from a conduit through a cut-out box at the base of the pole and thence inside the pole and through a pipe crook or "goose neck" to the lamp, and that the pole should be of neat appearance and strong enough to be readily handled without danger of breaking. In order to provide for setting the pole in a mass-concrete base the length was fixed at 35 ft. The reinforcement was designed to give a moment of resistance at the base of about 300,000 in. lbs. This provided greater strength than required for wind pressure, but it was considered advisable to give ample strength to withstand rough handling, so that the setting would not require too much care.

The poles are 11 ins. square at the base, and 6 ins. at the top, with the corners chamfered by inserting in the corners of the mold triangular strips 1 in. on a side. The reinforcement consists of one ⅝-in. square, twisted bar, 34 ft. long, in each corner, extending from about a foot above the base to the top, and two similar bars ½-in. square, 25 ft. long, in each side, extending to within 9 ft. of the top, so that the cross-sectional area of the reinforcement for the bottom part of the pole is 3.56 sq. ins., but for the top 9 ft. of the pole it is but 1.56 sq. ins. The bars were tied together at intervals of 4 ft., with two turns of No. 6 soft-steel wire, bent to a square, within which the rods were placed and secured at proper spacing by winding with stove wire. (Fig. 2.)

In the center of each pole is placed a standard black gas pipe, 1¼ ins. diameter, in two lengths of 15 ft., to lead the wires from the cutout box, near the base, to the top crook or goose neck. At the upper end of this pipe is placed a 2 × 1¼-in. reducer to connect with the 2-in. pipe forming the goose neck, and at the bottom it terminates in a 1¼-in. bend leading through the concrete to the cutout box. (Figs. 3 and 4). The top of the pole is finished with a special top casting, inclosing the upper end of the gas pipe, the reducer and the lower end of the goose neck (Fig. 5). Fitted above this is a special conical watershed casting so made that an annular space between the latter and the lower part of the goose neck may be calked with lead or asphalt insulating compound. (Fig. 5). The cast-iron cutout box, of special design, covers the series cutout and the outlets of both ducts. (Fig. 4). The pole steps are of ⅝-in. round galvanized iron, 10 ins. long, projecting 5 ins., and are bent near the end in order to clear the central pipe. (Fig. 1).

The wires are brought from the main conduits through 2-in. galvanized duct to the concrete base in which the pole is set, and up along the outside of the pole to the cutout box, located about a foot above the base. The connection from the lamp to the top crook or goose neck is made through a high-tension insulator and outlet bell. (Fig. 3).

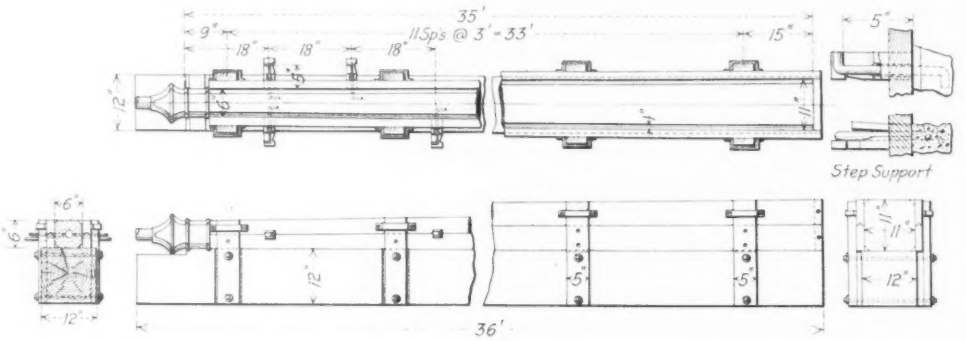

Fig. 1.

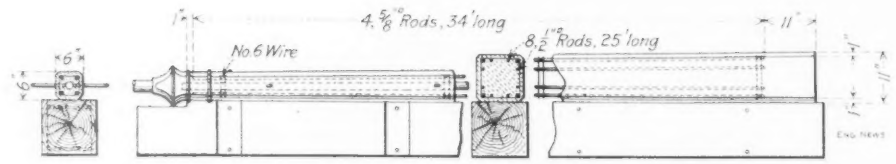

Fig. 2.

FIGS. 1. AND 2. FORMS AND REINFORCEMENT FOR REINFORCED-CONCRETE ELECTRIC-LAMP POLES, ST. MARYS FALLS CANAL, MICHIGAN.

The poles were molded in a horizontal position and the forms for the concrete are shown in Fig. 1. In order to support the pole uniformly without an excessive amount of blocking, the foundation timbers were of 12 × 12-in. fir, 36 ft. long, which were on hand. Six of these were planed on one side, and framed, and the remainder of the mold was made in duplicate. This permitted one pole to be made each day, and provided for removing the sides 24 hours after being made and leaving the pole on its firm support for about a week. The forms for the sides, secured by cleats bolted to the 12 × 12-in. timber, were so prepared as to be readily removed and placed on another timber, as indicated in Fig. 1. The method of supporting the pole steps shown was a little device that saved much time, and permitted the side pieces of the mold to be removed without disturbing the steps.

The rods for reinforcement having been purchased in the lengths needed, the first step in assembling them was to bend the wire ties or bands to the proper sizes to fit around the rods at intervals of 4 ft. and keep the rods to the taper which the shape of the pole required. These wire bands were made by bending around a hardwood mandrel. They were then placed in the

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form around the rods and each rod was tied with stove wire to each band at the point of crossing. This resulted in a unit of reinforcement that was quite rigid, and could be blocked up in place in the mold. The central pipe was then placed and secured, the steps adjusted with their wedges, and the top casting placed over the upper ends of the reinforcing rods ready to receive the concrete.

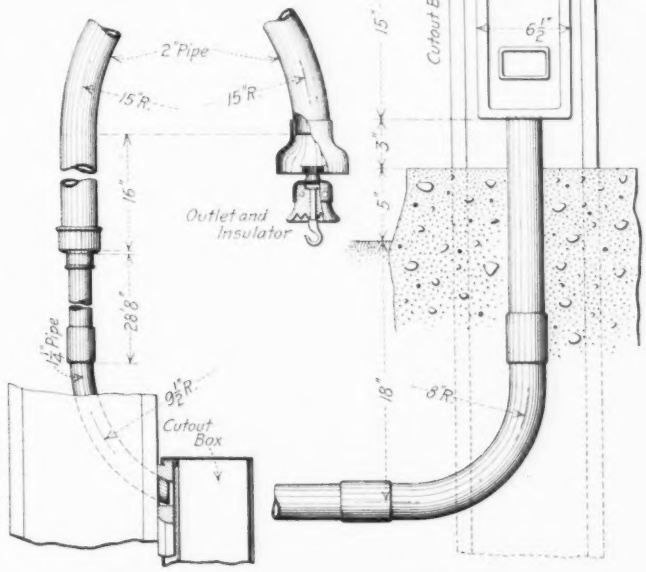

Fig. 3. Fig. 4.

FIGS. 3 AND 4. POLE AND BASE CROOKS, FOR A REINFORCED-CONCRETE ELECTRIC-LAMP SUPPORT.

posite the pole, was used to hoist it into position, the pole first turning about the hinge and later about the lower corner resting on the stone. Some poles, set nearer the canal wall than the above, were hoisted into position with the derrick without using the hinge. After the pole was in place and secured by guy lines, the concrete was mixed by hand and filled around it. Where the sides of the excavation stood up well no forms were used below the ground surface, but in case much caving had taken place, a rough mold was used for the lower part of the base. A plank form was used for the upper part above the ground surface, and this part was finished as usual after the removal of the form. After the concrete in the base had set the guys were removed and the pole wired for service. This consisted in laying, in a shallow trench, 2-in. galvanized duct from the manhole of the main conduits opposite the light to the 2-in. bend or crook imbedded in the base, (Fig. 6) and leading the necessary wires from this manhole to the outlet bell at the extreme end of the goose neck. The appearance of the pole after erection is shown in Fig. 8.

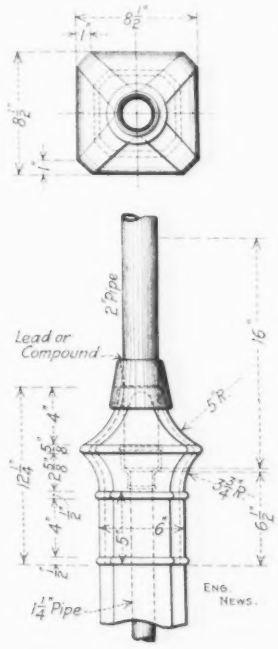

Fig. 5. Cast-Iron Cap for Reinforced-Concrete Pole.

The concrete aggregate was of limestone screenings passing a screen having 1-in. square openings. The proportions used were 1⅛ bbls. of cement, 7 cu. ft. of river sand and 14 cu. ft. of screenings. This batch made about 15 cu. ft. of concrete, or sufficient for one pole. It was mixed by hand, quite wet, and well puddled about the reinforcement. The top surface, forming one side of the pole, was finished as soon as ready. The following day the sides of the mold were removed and the two sides of the pole finished. (Fig. 2). After about a week, the pole was carefully tipped over on another 12 × 12-in. timber so that the remaining side could be finished, and when this was completed the pole was moved to storage. For finishing the sides the film of neat cement was removed by rubbing with a flat piece of sandstone and water, leaving a "sand" finish. Later, carborundum blocks were found well adapted to this purpose. Some of the poles first made were painted with a neat cement grout tinted with yellow ochre, but it was later decided that the natural gray of the concrete was preferable, especially in view of the fact that the concrete of the canal walls and other massive masonry was of this color.

When not governed by some special conditions, the poles are set 31½ ft. back from the face of the canal wall, in a block of mass concrete 3 ft. square by about 4 ft. deep. (Fig. 6). The top of this block is about 5 in. above the canal wall and has a 3-in. chamfer around the upper edge. The method of setting was as follows: After digging the hole for the base, a flat stone was placed in the bottom, at the desired elevation, to receive the bottom of the pole. The pole was then laid at right angles to the canal wall, with the butt over the hole and the top extending away from the canal. Along the lower side of the pole was secured an 8 × 8 in. timber, in which was cut, transversely, a semi-circular groove to fit over a timber roller about 6 ins. in diameter. This roller rested in two similar grooves, cut in 12 × 12-in. blocks staked to the ground, and formed a hinge about which the pole could revolve in a vertical plane at right angles to the canal wall. (Fig. 7). This hinge was so set that when the pole touched the stone at the bottom of the excavation it would be at an angle of about 45 degrees. A floating derrick, with 45-ft. boom, lying in the canal opposite the pole, was used to hoist it into position, the pole first turning about the hinge and later about the lower corner resting on the stone. Some poles, set nearer the canal wall than the above, were hoisted into position with the derrick without using the hinge. After the pole was in place and secured by guy lines, the concrete was mixed by hand and filled around it. Where the sides of the excavation stood up well no forms were used below the ground surface, but in case much caving had taken place, a rough mold was used for the lower part of the base. A plank form was used for the upper part above the ground surface, and this part was finished as usual after the removal of the form. After the concrete in the base had set the guys were removed and the pole wired for service. This consisted in laying, in a shallow trench, 2-in. galvanized duct from the manhole of the main conduits opposite the light to the 2-in. bend or crook imbedded in the base, (Fig. 6) and leading the necessary wires from this manhole to the outlet bell at the extreme end of the goose neck. The appearance of the pole after erection is shown in Fig. 8.

The material and labor required in the construction of one pole, and the cost, are given in Table I. The wages paid for eight hours work were as follows: Foreman, $3; carpenters, $2.25 to $2.75; cement finisher, $2.25; common labor, $2 per day. The entire cost of forms is included in the cost of 42 poles, although much of the material is good for further use. The pole was transported, from the yard to the point where it was to be set, on a derrick scow, and this transportation was quite expensive because a tug was kept constantly in service, to shift the derrick scow out of the way of passing vessels. The exact cost of this tug service is not known, and in the cost of transporting given below it is

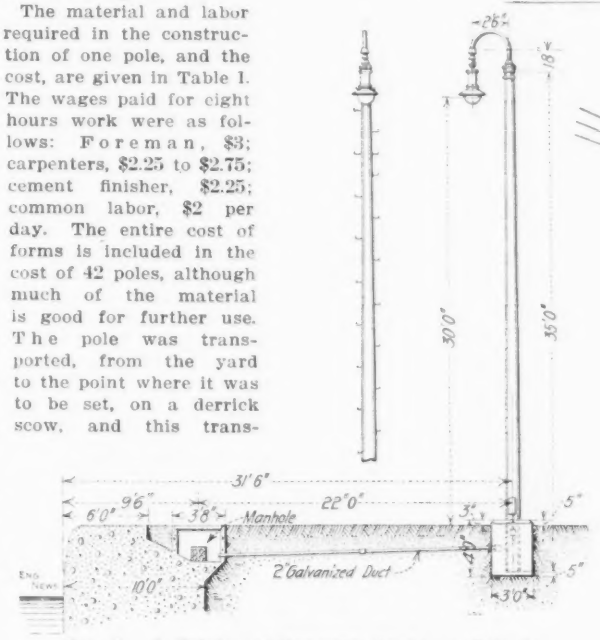

Fig. 6. A Reinforced-Concrete Arc-Lamp Pole in Place at St. Mary s Falls Canal.

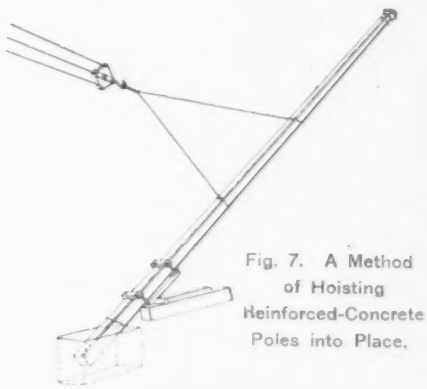

Fig. 7. A Method of Hoisting Reinforced-Concrete Poles into Place.

TABLE I.—COST OF REINFORCED-CONCRETE ELECTRIC-LAMP POLES FOR ST. MARYS FALLS CANAL.

CONSTRUCTION.

(Based on 40 poles.)

Materials—Reinforcement.		
350 lbs. cold twisted steel at 2.7 cts.	$9.45	
4 lbs. wire	.10	
		$9.55
Pipe, etc., built into the pole.		
26 ft. 1¼-in. steel gas pipe at 4.2 cts.	$1.09	
1 2 × 1¼-in. reducer (at top to attach crook)	.10	
1 1¼-in. bend (at bottom of pipe in pole).	.32	
22 10-in. galv. pile steps at 3 cts.	.66	
1 top casting	1.20	
		3.37
Concrete.		
1⅛ bbls. cement at $1.44	$1.62	
0.26 cu. yd. sand at 55 cts.	.14	
0.52 cu. yd. screenings at $1.10	.57	
		2.33
Forms (for 42 poles).		
Lumber	$75.12	
Bolts, pail and iron	10.45	
Labor, building	189.67	
Total $275.24; each =		6.55
Labor and Transporting Materials.		
Superintendence	$1.42	
Hauling material, labor and tug service	2.85	
Assembling forms	1.55	
Assembling reinforcement	1.53	
Concreting, stripping and dressing	4.18	
Miscellaneous, blacksmith & contingencies.	3.14	
Total labor and tug service		14.67
Total cost of pole in yard		$36.47

TRANSPORTATION.

Labor	$0.63	
Tug (estimated)	3.00	
Total		$3.63

ERECTION.

(Based on 15 poles and including concrete base.)

Materials.		
1⅛ bbls. cement at $1.44	$1.99	
0.46 cu. yd. sand at 55 cts.	.25	
0.46 cu. yd. screening at $1.10	.50	
1.15 cu. yds. broken stone at $1.10	1.26	
Transporting, 3 tons, at 50 cts.	1.50	
		5.50
2-in. bend and coupling		.92
Labor.		
Superintendence	$2.81	
Excavation and backfill	2.54	
Erection with derrick	5.97	
Mixing & placing concrete, including forms	4.17	
Miscellaneous and contingencies	2.20	
		17.69
Total, base and erection		$24.11

WIRING AND FITTING.

(Based on nine poles.)

Materials.		
1 watershed	$0.12	
1 2-in. crook or goose neck	1.25	
1 outlet bell	0.20	
1 cutout box	1.25	
1 pothead and cutout	4.40	
80 ft. No. 6 rubber covered wire, with weatherproof braid at 16¼ cts.	13.00	
Miscellaneous supplies	0.30	
Total, material		$20.52
Labor Etc.		
Labor of wiring and fitting	$3.63	
Transportation of materials & contingencies	1.52	
		$5.15
Total, wiring and fitting		$25.67

SUMMARIZED COSTS.

Pole as molded, including materials used.	$36.47
Transportation of pole to site	3.63
Erection, including concrete base	24.11
Wire, cutout, and other accessories through base and pole to lamp	20.52
Wiring and fitting up pole	5.15
Total cost in place and wired	$80.88

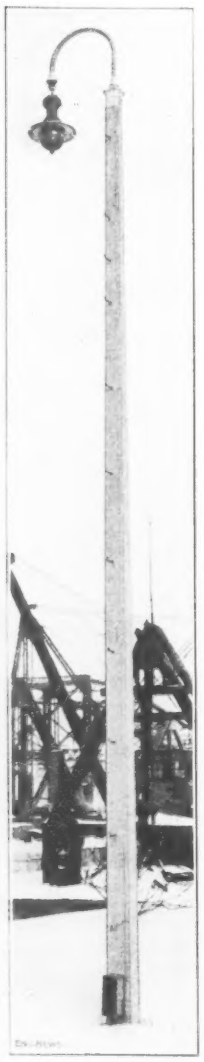

Fig. 8. Reinforced-Concrete Arc-Lamp Pole in Place, St. Marys Canal.

estimated at $3 per pole, which added to the cost of labor, $0.63, gives $3.63 as the cost of transporting.

The figures for construction, transportation and erection, however, do not include all the expense of placing the pole in service ready to receive its lamp. Therefore there is appended the cost of materials used to form the connection between the lamp and the end of the duct leading to the main conduit, that is, from where the wires reach the concrete base to the lamp. This cost is based on the materials used for nine poles; in future work the above cost will be reduced about $8 by the use of loom tubing for the rubber covered wire in place of the weather-proof braid.

Considering the fact that the life of a wooden pole is quite limited and that such poles must be painted annually, at a cost of about a dollar, there seems to be no question that the concrete pole is more economical, especially where the wires are placed underground. The basis for this statement is seen in the figures below.

For comparison with these reinforced-concrete poles, an estimate may be made of the cost of a wooden pole, with a pipe leading up the outside, with a goose neck at the top, and set in a concrete base, as follows:

1 12 × 12-in. 36-ft. stick of fir at $30 per M. ft. B. M.	$12.96	
Pipe, steps and top casting	3.37	
4 man-days labor trimming pole at $2.25.	9.00	
Cost of pole in yard		$25.33
Transportation of pole to site		3.00
Erection, including concrete base		22.00
Wiring, etc., same as for concrete pole		25.67
Total cost of wooden pole in place and wired		$76.00

The strength of the concrete pole was determined by a test of a pole molded for the purpose, without the central pipe, top casting, and steps, but in other respects the same as the regular poles.

Five feet in length at the butt of the pole rested on a mass of masonry, about 3 ft. above the ground, to which it was firmly secured by two pairs of fox-wedge bolts, one pair being placed 12 ins., and the other 42 ins., from the end of the pole. Near the top, and 29 ft. 7 ins. from the edge of the masonry, was hung a platform which could be loaded with cast-iron weights. A view of the pole under test is shown in Fig. 9. The record of the test is given in Table II.

It is seen that the pole developed a moment of resistance of 528,000 in.-lbs. before showing any signs of failure. The yield point appears to have been reached when the bending moment was 628,000. The maximum moment developed was 800,000 in.-lbs. At this point the measured deflection was 27.2 ins., but as the loading platform touched the ground, this measurement is somewhat too low.

The arrangements at hand did not permit carrying the experiment any further, and the most important sign of failure was the appearance of the tension cracks in the base back of the edge of the supporting masonry. One of these started at the top, 34 ins. from the end of the pole, and extended diagonally downward to a point 50 ins. from the end at the lower surface; another one started 46 ins. from the end at the top and reached the lower surface 55 ins. from the end of the pole; the third crack mentioned in the notes was between these two and very short. The holding down bolts were, as already stated, 12 ins. and 42 ins. respectively, from the end of the pole. After the load was removed the deflection decreased to 12¾ ins., the small tension cracks along the pole in the upper side, extending about half the depth, remaining plainly visible.

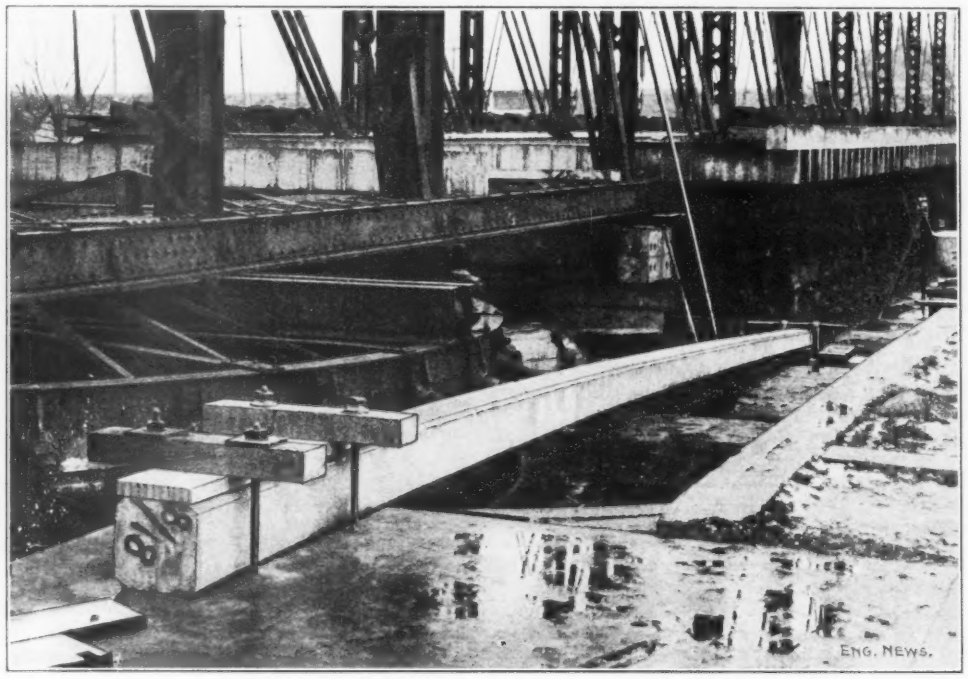

FIG. 9. TESTING A REINFORCED-CONCRETE ELECTRIC-LAMP SUPPORT.

TABLE II.—RESULTS OF TEST OF REINFORCED-CONCRETE ELECTRIC-LAMP POLE.

Time, p. m.	Applied load, lbs.	Bending moment, in.-lbs.	Deflection, ins.	Remarks.
2:22	2,030 (Dead	397,800	7.0	Weight of pole beyond support.
	90	429,740	8.1	Weight of platform.
	232	480,200	10.2	No cracks visible.
	300	504,600	11.2	No cracks visible.
	368	528,700	12.2	No cracks visible.
2:40	436	552,600	13.4	Seem to be slight cracks on tension side along whole length.
3:10	436	552,600	13.9	Deflection increased 0.5-in. in 30 mins. with no increase of load.
	507	577,800	14.7	No change in cracks.
	577	602,600	15.7	No change in cracks.
	648	627,800	16.9	No change in cracks.
	720	653,300	19.6	No change in cracks.
	788	677,800	21.4	Small cracks develop near base on tension side.
	856	701,800	22.6	No change.
	925	726,300	23.1	One diagonal tension crack developed in base back of edge support—south side only.
	994	750,800	24.7	Two additional diagonal tension cracks appeared on south side only, back of edge of support.
	1,062	774,800	26.5	One diagonal tension crack developed on north side.
3:45	1,132 (Dead	799,800	27.2	Three diagonal tension cracks on each side—open up slightly. Platform touches ground.
3:55	2,030)	....	12.7	

Standard Tests of Drain Tile and Sewer Pipe.*

By A. MARSTON† and A. O. ANDERSON.‡

It has become apparent that there is great need of standard test requirements for sewer pipe and drain tile. Occasional notices appear from time to time in the engineering periodicals showing that inspections of old pipe sewers frequently show a considerable percentage of cracked pipe. During the past year an especially disastrous failure of large cement drain tile occurred in Sac County, Iowa, the damage running up to several thousand dollars. Following this failure, intelligent and reliable experts have made examination of a number of large tile drains in the northern part of the state, and they report that many of the pipe in such drains are found cracked, when the depth of earth filling exceeds 7 or 8 ft.

It is of great importance, therefore, that the strength of sewer pipe and drain tile should be carefully investigated, and that standard tests should be devised and standard strength specifications adopted which will insure against failure. In the absence of standard specifications for tests, great differences in the methods of making tests have developed in practice, with the result that our knowledge of the strength remains extremely deficient, and that it is as yet impossible to make a reasonable standard strength specification. It is exceedingly important that uniform methods should be adopted and used by all.

The cardinal qualities of drain tile and sewer pipe are: (1) the quality of the material, and (2) the strength of the pipe.

The quality of the material is a cardinal quality, because the pipe will disintegrate and go to pieces unless the material of which it is made is of such durable quality as to resist all disintegrating agencies. A cement tile must be made of hard, dense, uniform, and comparatively impervious concrete in order to resist the action of destructive agencies, and to prevent their ready penetration into its pores. In the same way, soft and underburned sewer pipe or clay drain tile are unsatisfactory, since such pipe cannot resist the action of freezing and thawing, and may disintegrate from other agencies. Also, a laminated structure in clay drain tile or sewer pipe prevents resistance to frost and causes failure. High bearing strength of the pipe, as a whole, is not a satisfactory indication of the quality of the material from which the pipe is made, for high strength may be secured by using thick walls. Drain tile or sewer pipe with thick walls may be strong enough, and yet may be porous and disintegrate.

Two simple tests may be made to determine the quality of the material of which drain tile or sewer pipe are

*Abstract of a paper presented at the annual meeting of the Iowa Engineering Society at Des Moines, Iowa, Feb. 15-17. It has been presented also before the Iowa Cement Users' Association, the Iowa Brick & Tile Manufacturers' Association, and the Iowa State Drainage Association. The first two of these organizations have already adopted the specifications proposed. Prof. Marston is to present the subject also at the annual meeting of the American Society for Testing Materials, in June.

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made: the absorption test and the determination of the modulus of rupture. The absorption test is of great importance for cement and clay tile. In the case of cement tile, the agencies tending to destroy the concrete cannot act with much rapidity unless they obtain access to the interior of the concrete walls. In the case of clay tile, the action of freezing would not be of much importance unless water could obtain access to the interior of the walls. Hence, the absorption test has a greater importance in testing drain tile and sewer pipe than in the case of most other materials of construction. For this reason, and because it is simple and easy to make, we advocate it as one of the standard tests for drain tile and sewer pipe.

By the modulus of rupture is meant the tensile breaking strength of the material of the pipe wall, as calculated from the results of the bearing strength test. The determination of the modulus of rupture requires no independent test of the material, and it will probably give an important indication of the quality of the material. The modulus of rupture for drain tile and sewer pipe, calculated as above, exactly corresponds to the modulus of rupture of paving brick calculated from the results of transverse tests.

Hence, we recommend three standard test requirements for drain tile and sewer pipe: (1) the per cent. of absorption, (2) the modulus of rupture, and (3) the bearing strength of the pipe. These three test requirements involve two standard tests: the absorption test and the bearing strength test.

Methods of Making Absorption Tests.

The making of absorption tests has been standardized for paving brick, but not for other materials. The standard method for paving brick can be used as a basis from which to start in determining the standard method for drain tile and sewer pipe. Studying these standard requirements, there seems to be no reason for varying the process in any material point except in the case of the time of immersion. In the case of paving brick, the standard time of immersion is 48 hours. Our tests of drain tile and sewer pipe, as well as those of brick, indicate to us that it will be safe to reduce the standard time of immersion to 24 hours for drain tile and sewer pipe. As this cuts the time required in half, we recommend this change. Our full standard specifications will be found given in detail below.

Methods of Testing Bearing Strength.

In tests of bearing strength of drain tile and sewer pipe great difference in practice has developed. It will be unnecessary to discuss all of these. For example, it has been the practice of some to completely surround the pipe, during the test, with sand enclosed in heavy framework, but this method is no longer used, so far as the knowledge of the authors extends. Three methods have survived to such an extent that they are worthy of further discussion.

(1) Concentrated Loading.—In this method the test load is applied along a line, or a very narrow strip, at the top and bottom of the tile. Some plan must be used for insuring comparatively uniform distribution of the load, and for this purpose it is considered necessary to introduce a packing material of some kind between the bearing block and the pipe. Prof. Talbot (University of Illinois) uses a piece of fire hose; Mr. Boynton (Universal Portland Cement Co.) uses a strip of rubber packing.

There are numerous objections to this method: (1) the test does not subject the pipe to forces approximating those which it must stand in the ditch. (2) Even when packing is used, there is no method of securing very uniform distribution of the load upon the pipe, especially if the pipe is slightly warped, which is very apt to be the case with hard-burned clay pipe. (3) The method does not admit of satisfactory distribution of pressure on the bells of sewer pipe, as well as on the straight part. (4) The packing used must, by its yielding, introduce splitting stresses. The use of packing has been abandoned for crushing tests of building materials for this reason. The splitting stresses would be of especial importance in a strength test of drain tile or sewer pipe, in which failure must occur by tension.

As a variation of the method of concentrated loading, Mr. Boynton has proposed supporting the pipe on two half-rounds at the bottom, spaced 2½ ins. apart, and applying the load by one half-round at the top using strips of rubber packing at both top and bottom. The authors consider this method open to all the objections already stated, and to the further objection that it introduces a method of loading which varies for different sizes of pipe. If the 2½-in. spacing of the lower half-rounds is adopted for 6-in. pipe, then to obtain the corresponding loading for a 12-in. pipe the spacing should be 5 ins., 10 ins. for 24-in., 12½ ins. for 36-in., and so on. If this so-called three point method were adopted, therefore, the strength of any particular diameter of pipe would depend upon the method of testing as well as the quality and dimensions of the pipe.

(2) The Combined, or Brooklyn Method.—For many years the engineers of the borough of Brooklyn, N. Y., have provided regular strength tests and requirements in their specifications for sewer pipe. At first they surrounded the pipe by sand in their test, but now apply a concentrated load along the upper part of the straight portion of the sewer pipe, while bedding the pipe in sand at the bottom. No load is applied to the bell. This method undoubtedly gives more nearly the actual strength of the tile in the ditch than the method of concentrated loading. But we believe it will give materially less loads than a sewer pipe or drain tile will carry under actual average ditch conditions, if they are laid with proper precautions. Moreover, it is open, so far as the top loading is concerned, to the other objections raised to the method of concentrated loading.

(3) Recommended Standard Method for Testing Bearing Strength.—The Engineering Experiment Station of the Iowa State College has been making tests of drain tile and sewer pipe for several years. When this work first began, we made a careful study of actual ditch conditions, and devised a standard method which reproduced these conditions as far as practicable in a laboratory test which could be carried out with uniformity by different experimenters in different laboratories. The Engineering Experiment Station is just publishing a bulletin upon standard tests of drain tile and sewer pipe, describing this standard method in detail, giving plans for inexpensive testing machines by which it can be carried out, and giving the results of several hundred standard tests of cement and clay drain tile and sewer pipe.

In this method the pipe is bedded for one-fourth its circumference at both top and bottom in sand, and the load is uniformly distributed over the upper surface of the top bedding of sand. This method has proved very satisfactory during several years of use. We have had opportunity to make comparison of the results with the actual loads of earth filling which have caused failure of large pipe in drainage ditches, and our standard method seems fairly to indicate the strength actually developed in the ditch under average actual conditions.

Our standard method enables the load to be uniformly distributed over the pipe, regardless of unimportant irregularities in the shape. It avoids all splitting stresses due to packing material in the bearings. Sand is a material which can readily and cheaply be obtained in any community for the standard test. By marking the pipe in quarters before testing, accurate bedding in the sand is readily insured both above and below, and the method is, therefore, accurate.

The method permits the testing of pipe with bells as readily as those without, since the bells (as well as the straight pipe) can be embedded in the sand bearing. We have made numerous tests of sewer pipe with bells, and find no difficulty in such work. It can be adopted for field tests without any testing machine whatever, by simply piling brick, sacks of cement or earth, or other convenient material upon the pipe.

The method is equally fair to cement pipe and to clay pipe. It is a simple method which can be carried out by any competent engineer, or by any competent superintendent of a factory. It does not require translation to enable its results to be understood by people who are not engineers or manufacturers, which is not the case when such tests are made with concentrated loads, since these do not give the actual strength of the pipe as used in the ditch. For all these reasons, therefore, we strongly recommend the adoption of this method as the standard method for testing the bearing strength of drain tile and sewer pipe.

Testing Machines for Bearing Strength.

To enable the standard strength test to be made where drainage or sewerage work is in progress, we have devised home-made testing machines which are within the reach of every city, county, drain tile or sewer pipe factory, or even the means of the drainage or sewerage engineer. Our "Ames Junior" testing machine consists of an ordinary platform scale of 2,000 lbs. capacity, placed in a wooden framework, with an ordinary jack-screw to apply the pressure. We find that the 2,000-lb. scale can readily be loaded to 5,000 lbs. without injuring it. In addition, we have devised a lever by which, using a longer framework, the same machine can be used for tests up to 10,000 lbs. without loading the scales beyond the 2,000-lb. rated capacity. We designate this larger machine the Ames standard testing machine. Either of these machines can be built at a cost of $50 to $60.

Prof. Talbot, of the University of Illinois, has devised a home-made testing machine in which the load is applied simply by a lever, and which, with a platform scale for weighing the load, would probably cost little if any more than those which we have devised. Mr. C. W. Boynton has devised a machine similar to our Ames "Junior" machine which could probably be made for $75, including scales. Although we do not advise the use of his so-called "three-point" bearing, yet his machine could be used with our standard method by a slight variation in its construction.

Specifications for Standard Absorption Tests.

1. The specimens shall be approximately 3 ins. square, and shall extend the full thickness of the pipe wall, with the outer skins unbroken.
2. Five individual tests shall constitute a standard test, the average of the five, and the result for each specimen, being given in the report of the test.
3. Each specimen shall be dried in an oven or by other application of artificial heat, until it ceases to lose further appreciable amounts of moisture when repeatedly weighed.
4. All surfaces of the specimens shall be brushed with a stiff brush before weighing the first time.
5. The specimens shall be weighed immediately before immersion, on a balance or scales capable of accurately indicating the weight within 0.1%.
6. The water employed shall be pure soft water, at the air temperature of a room which is artificially heated in cold seasons of the year.
7. The specimens shall be completely immersed in water for a period of 24 hours.
8. Immediately upon being removed from the water, the specimens shall be dried by pressing against them a soft cloth or a piece of blotting paper. There shall be no rubbing or brushing of the specimen. The reweighing shall be done with a balance or scales capable of accurately indicating the weight within 0.1%.
9. The result of each absorption test shall be calculated by taking the difference between the initial dry weight and the final weight, and dividing the remainder by the initial dry weight.

Specifications for Standard Tests of Bearing Strength.

1. The specimens shall be unbroken, full sized samples of the pipe to be tested. They shall be carefully selected so as to represent fairly the quality of the pipe.
2. Five individual tests shall constitute a standard test, the average of the five and the result for each specimen being given in the report of the test.
3. The specimens shall be dried by keeping them in a warm, dry room for a period of at least two days prior to the test.
4. Each dried specimen shall be weighed on a pair of reliable platform scales just prior to the test.
5. Each specimen shall be accurately marked, with pencil or crayon lines, in quarters, prior to the test. Specimens shall be carefully bedded above and below in sand for the one-fourth circumference of the pipe, measured on the middle line of the tile wall. The depth of bedding above and below the tile at the thinnest point shall be equal to one-fourth the diameter of the pipe, measured between the middle lines of the tile walls.
6. The top bearing frame shall not be allowed to come in contact with the tile or with the test load. The upper surface of the sand in the top bearing shall be carefully struck level with a straight edge, and shall be carefully covered with a heavy, rigid top bearing, with lower surface a true plane, made of heavy timbers or other rigid material capable of uniformly distributing the test load without any appreciable bending. The test load shall be applied at the exact center of this top bearing in such a way (either by the use of a spherical bearing, or by the use of two rollers or rods at right angles) as to leave the bearing free to move in both directions. In case the test is made without the use of a machine, and by piling on weight, the weight may be piled directly on a platform resting on the top bearing; provided, however, that the weight does not touch the top frame holding the sand, and that the weight is piled in such a way as to insure uniform distribution of the load over the top surface of the sand.
7. The frames for the top and bottom bearings shall be composed of timbers so heavy as to avoid any appreciable bending by the side pressure of the sand. The frames shall be dressed on their interior surfaces. No frames shall come in contact with the tile during the test. A strip of soft cloth may be attached to the inside of the upper frame on each side along the lower edge to prevent the escape of sand between the frame and the tile.
8. The sand used for bedding the tile at top and bottom, shall be washed sand which has passed a No. 8 screen. It shall be dried by keeping it spread out thin in a warm, dry room.
9. The test load shall be applied gradually and without shock or disturbance of the tile. The application of the load shall be carried on continuously, and the tile shall not be allowed to stand any considerable length of time under a load smaller than the breaking load.
10. The total breaking load shall be taken as equal to the total top load, including the weight of top frame, sand for top bearing, top bearing timbers, etc., plus five-eighths of the weight of the pipe. This total load shall be divided by the length of the pipe in feet so as to give the bearing strength per linear foot of pipe.

Specifications for Calculating the Modulus of Rupture.

The modulus of rupture for drain tile and sewer pipe shall be computed from the results of the standard test for bearing strength, according to the following rule:

Divide the bearing strength per linear foot by 12, multiply the quotient by the radius of the middle line of the tile wall expressed in inches, and divide this product by the square of the minimum thickness of the tile wall at top or bottom, also expressed in inches. This quotient will be the modulus of rupture of the pipe expressed in pounds per square inch.

DIAGRAMS FOR DETERMINING STEAM AND EXhaust pipe sizes without computation have been prepared by Mr. W. J. A. London, Chief Engineer of the Terry Steam Turbine Co., with the idea of saving the work of computing the proper pipe size for each individual installation. The curve sheet for steam pipe sizes enables one to read off the pipe size directly when the horse-power, water rate per horse-power and steam pressure are given. The exhaust-pipe size is read off similarly, from a second curve-sheet, when the horse-power, water rate and back pressure (or vacuum) are known.

The range of the curves is from 0 to 800 HP., 10 to 90 lbs. water rate, 24 to 29 ins. of vacuum and 60 to 200 lbs. steam pressure.

The pipe sizes shown by the diagram are based upon a steam velocity of 6,000 ft. per min. (dry saturated steam.) The exhaust pipe diagram resembles the other, but has vacuum diagonals in place of the steam pressure diagonals of the diagram described. The exhaust pipe sizes are based on a velocity of 24,000 ft. per min.

Reduced copies of the diagrams can be obtained from Mr. F. D. Herbert, General Sales Manager, Terry Steam Turbine Co., 90 West St., New York City.

Water Waste Surveys in Chicago.[1]

By T. C. PHILLIPS.[2]

One of the most serious problems that confronts those in charge of the Chicago water-works is how to cope with the steadily increasing rate of consumption of water. What becomes of the great volume of water which is pumped may perhaps be best answered by first giving a few figures relative to the water supply. The present nominal capacity of the Chicago water-works system is about 635,000,000 gals. per 24 hours, including the Roseland pumping station (50,000,000 gals. per day). The average daily pumpage per day for the year 1910 was 517,000,000 gallons, the maximum daily pumpage was at the rate of 566,000,000 gals. per 24 hours, while the maximum daily pumpage was at the rate of 499,000,000 gals.

The area of the city is approximately 190 sq. mi. The system of water mains distributed over this great area consists of 2,271 miles of pipe, 23,980 hydrants and 19,710 gate valves. The water supply is pumped into this system from eight large pumping stations and a portion is repumped from three small stations in the out-lying territory. The supply is obtained from Lake Michigan through five intake cribs and brought into the city by tunnels under the lake, extending to the pumping stations along the shore and in the interior of the city.[3] There are about 36 miles of tunnels in operation. As soon as the new Roseland pumping station is completed, an additional intake crib and about ten additional miles of tunnels will be placed in service.

The average pressure in the mains at the pumping stations is about 50 lbs. and the average pressure throughout the city is about 57 ft. head or 25 lbs. The total number of services of all sizes in use at the end of 1910 was 254,446. The total number of meters of all sizes was 15,032 or 5.9% of the total number of services. About 18% of the water pumped passes through meters.

The city has a flat meter rate of 62½ cts. per 1,000 cu. ft., which is approximately a rate of 7 cts. per 1,000 gals. The total revenue received for water for the year 1910 amounted to $5,448,257. The revenue received for meter water this year was $2,429,432, and for unmetered water by frontage service, $3,018,826. The daily per capita consumption based on the total pumpage of 517,000,000 gals. per day and a population of 2,185,000 amounts to 235 gals.

The waste water surveys were begun, in a small way, about 1906. The first appropriations were small, but were gradually increased until in the past two years the city appropriated $55,000 each year to carry on this work. For the year 1911 the city appropriated $154,000 to promote water survey work. The amount of the appropriation for each year so far has been returned to the city within the first year.

The method of carrying on the surveys is what is known as the Deacon system, but a pitometer is used to measure the water instead of the Deacon waste meter.[4] The surveys were begun in the central portion of the city by laying out as nearly as possible ¼-mile sections and measuring the water supply flowing into them for a period of one week. After measuring the supply the districts were subdivided to determine the water consumption street by street. Following subdivision work, house to house inspections were made to ascertain the plumbing leakage. Wherever defective plumbing was found the owner or tenant was notified to make repairs. After the repairs were completed, a resurvey of the district was made to determine the amount of leakage due to defective plumbing.

The re-survey also showed approximately the amount of underground leakage in the street. A fairly close determination of this loss was made by assuming the rate of flow during the period from midnight to about 4 a. m. to be mostly due to underground leakage. Some allowance, however, was made for legitimate usage. This allowance varied from 10 to 50% of the minimum night rate of flow, depending upon the class of consumption.

PLUMBING LEAKAGE.—Where the water-supply is unmetered, the consumer generally pays little attention to the amount of water used or wasted on his premises so long as he obtains sufficient water for his needs. For this reason, where the property is not metered, house-to-house inspections should be made from time to time and the owner or tenant should be required to repair all plumbing fixtures found leaking. Such inspections generally require two or more visits. After the first inspection the owner or tenant was generally given ten days' notice to make plumbing repairs. Upon failure to do this the water was turned off until the request to repair was complied with. This rule did not work a hardship where there was no attempt made to evade the request, and an extension of time was usually granted when it was found the owner was complying with the request in good faith.

The second inspection was made ten days after the notices were sent out to ascertain if the order to repair was complied with and also if the repairs were made properly. It was not uncommon to find repairs paid for in good faith by the owner, which were unsatisfactory. A little instruction on the part of the city plumbing inspector usually served to obtain good workmanship. The plumber making repairs learned that it was more profitable to make repairs properly, particularly when the work was inspected by a competent inspector. By the time of the third and sometimes the fourth inspection of the premises was made, the plumbing leakage was stopped and good repairs obtained.

It is very important that the house-to-house inspections and the plumbing repairs be carefully and thoroughly made. Otherwise determinations of the amount of leakage due to defective plumbing and also due to underground leakage and losses outside of the meter will be misleading. During 1910, 32 plumbing inspectors were employed almost constantly on this inspection work. They were divided into field parties of ten men each and were assigned to ¼-mile districts previously surveyed by the pitometer field party. The time necessary to thoroughly inspect and repair the plumbing in a district averages from four to seven weeks. The plumbing leakage in the territory surveyed wastes about 33% of the water supplied.

The elimination of the plumbing leakage was not the only benefit derived by repairing defective plumbing. A considerable increase in the water pressure in each district was generally found after making repairs. Comparatively few complaints of low pressure were received during the past summer months from those districts in which the plumbing was repaired. The following statement is quoted from a report by Mr. John Ericson, City Engineer, and is given as an illustration of the effect of reducing waste and leakage.

> If half of the water pumped is wasted or leaks away, the pumps have to force into the mains twice as much water as is otherwise necessary, and this means a velocity in the pipes of at least twice the necessary velocity. Since the friction increases as the square of the velocity, the conclusion to be drawn is that if the pumpage can be decreased 50%, the pressure can be increased four times without any additional expense, or in other words, the same pressure as before can be maintained at about one-fourth the cost of fuel.

UNDERGROUND LEAKAGE.—This loss of water is due principally to defective mains and old service pipes. The loss from defective street mains is due mainly to joint leakage, to electrolysis, and occasionally to broken pipes. The joint leakage is comparatively small, but the losses due to electrolysis are often quite serious. The leakage caused by electrolysis is confined to sections or zones and is not believed to be serious over the general area of the city. In the territory surveyed the leakage wastes from 25 to 35% of the supply. The most important underground leakage is due to the old, unused and abandoned service pipes in the streets, that have opened or given away under pressure. The reason for this loss may be understood when we stop to consider the great number of such service connections and the constant changes and liability to damage of service pipes after installation.

When a water main is laid or extended, a service pipe is laid every 25 ft. on both sides of the street. As the street grows or improves, some of these services are connected up, but a great many of them are never used. Later on those in use are frequently replaced with larger ones. The boxes at the curb or walk, which were installed to control the services, very often disappear with street improvements or for other reasons, so that the service pipe cannot be located. Unfortunately when a service pipe begins to leak, the water usually finds its way to the sewer instead of showing on the surface of the street and the loss goes on indefinitely.

The method which we have adopted for determining underground leakage is to measure the flow at night, street by street. Where there are gate valves on the main at street intersections the leakage for any block can be measured by the pitometer. If the leakage is too small to create sufficient velocity in the main, the amount of the leakage is difficult to determine by this method. Small losses may be measured by closing the gate valve on the inlet and by-passing the water through a meter.

One of the features of the survey during 1910 was the street improvement work, which consisted in testing the street mains before the paving was laid. Where the leakage was found excessive the mains were uncovered, and recalked and all unused services disconnected. The mains inside 'the "loop" district or principal business section have been pretty thoroughly overhauled in this manner. Beyond this territory, the appropriation for operation and maintenance did not permit this work on an extensive scale. This improvement work is sufficiently important to be carried on constantly (as is done by the Peoples Gas Light & Coke Co.), particularly at the present time, when the tendency is toward heavier paving foundations.

Western Ave. was recently paved for several blocks both north and south of Chicago Ave. Prior to paving, the 12-in. main in the street was tested for leakage and found to be wasting considerable water. In one block this amounted to 750,000 gals. per day. The sewers in the immediate vicinity were inspected and clear water was found running in them. There were 26 services in this block from the main, three of which were in use and 23 were completely broken off at the top. This 12-in. main was laid in 1895 and it is believed the settlement of the dirt and rock fill tore away the lead service pipes. A 12-in. main in Plymouth Court, from Polk to 12th sts., was uncovered and stripped on account of the heavy leakage found by the subdivision survey. A total of 130 services were found connected to the main, 18 of which were leaking and only 21 in use. The loss from the 18 leaky services amounted to 325,000 gals. per day. All the services not in use were cut off and plugged at the main. The cost of stripping this main, which lay under a street car track, was less than $2,000, while the saving in the cost of supply amounted to over $3,000 the first year.

It is not intended to convey the idea that the underground leakage is everywhere as serious as the cases just cited. The subdivision tests show portions of districts where the night flow is small and stripping the mains is not warranted. In nearly every district, however, some streets were found in which the leakage is high, which would pay a substantial return on the cost of stripping the main, including the cost of replacing the paving. The surveys show that the underground leakage in the streets is more or less universal and generally small but occasionally it is quite serious. The leakage will increase and become a menace if steps are not taken to eliminate it. Provision should be made in the appropriation for operation and maintenance each year to strip the mains of old services not in use, where the underground leakage is found to be excessive. The work could be done at a minimum cost at the time the paving is relaid.

METERS.—The number of services in use is approximately 254,000, about 6% of which are metered. Many American cities have adopted the policy of totally metered systems. This policy has many advantages, but the important consideration with Chicago at present is not the question of such a policy so much as is the question of more meters. The principal advantage of a meter is, that it is the best waste water inspector and perhaps the best regulator of revenue. A meter, however, will not stop the underground leakage.

Milwaukee, a practically totally metered city, has an unaccounted-for supply of about 40%. Cleveland, according to a report of Mr. Edward W. Bemis, accounts through meters for all but 8% of the water leaving the pumping station. Allowing for a little slippage of meters there seems to be very little or no unaccounted for or underground leakage in Cleveland.

The effect of metering 94% of the services in Cleveland resulted in decreasing the consumption about 70 to 80 gals per capita. Greater results from metering alone in Chicago may not reasonably be expected as the percentage of underground leakage is about four times as large, and, therefore, a smaller percentage of water pumped remains to be effected. The present high daily per capita consumption in Chicago could be decreased greatly by metering and by overhauling the underground work, wherever the leakage found justified the repairs. The result of this procedure would probably result in decreasing the present consumption 50%.

GENERAL.—Many cities are compelled to adopt measures to conserve their water supply because the supply is limited. In Chicago, however, this is not the case as there is an abundant supply close at hand. Unfortunately, however the water does not flow into the water mains but has to be pumped at a great total cost. In the 50 or more districts surveyed up to the present time in the older and central portions of the city the indications point to the fact that only about 33% of the water pumped is actually used. The remainder is lost through defective plumbing fixtures and by underground leakage. Some one has to pay for the water that is wasted, and when the unaccounted for supply becomes such a large percentage of the total pumpage the question of curtailing the waste and leakage is a vital one.

The total amount of water saved for 1908 was 9,939,000 gals. per day; 12,613,000 gals. per day for 1909, and 15,000,000 gals. per day for 1910. The Water Survey Division spent about $35,000 for survey work in 1908, about $44,000 in 1909, and approximately $55,000 in 1910. These figures show that it cost about 1 ct. per 1,000 gals. to save water based on a permanency of one year for plumbing repair work. The life of repair work is undoubtedly much greater than this, possibly 4 or 5 years and a portion of it may be said to be permanent work.

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[1]Abstract of a paper read at the annual meeting of the Illinois Water Supply Association, at the University of Illinois, Feb. 21-22.

[2]Engineer of Water Surveys, Department of Engineering, City Hall, Chicago.

[3]The intake system of the Chicago water-works system was described in Engineering News, Oct. 18 and Nov. 8, 1900; Aug. 31, 1899, and Nov. 14, 1907.—Ed.

[4]The earlier work with the Cole-Flad pitometer was described in our issue of Dec. 15, 1904.—Ed.

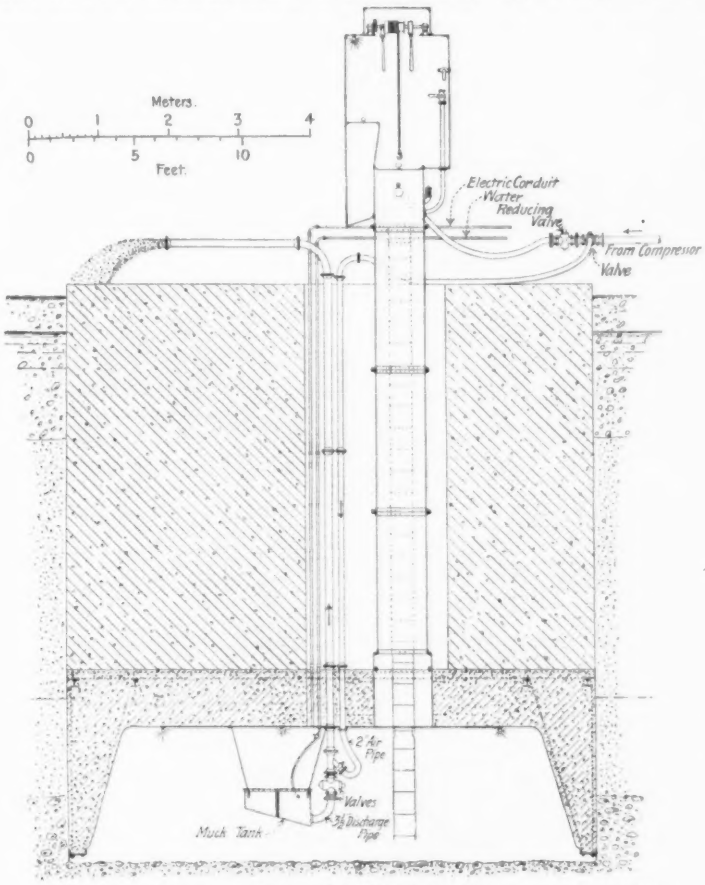
SURFACE-RAILWAY CONDITIONS in Providence, R. I., and Buffalo, N. Y., are to be investigated by Mr. B. J. Arnold. In Providence the immediate object is the improvement of the service, and Mr. Arnold has been retained by the Mayor and Common Council.

In Buffalo, it is proposed to refinance the International Traction Co. The Public Service Commission for the Second District of New York required an appraisal of the physical property as a part of this work. The choice of Mr. Arnold as appraiser was made by the company and approved by the Commission.

A Pneumatic Muck Ejector with Auxiliary Air Supply.

A specialized form of pneumatic muck ejector used in caisson foundation work at Aarau, Switzerland, is described by G. Lüscher, its designer, in the "Schweizerische Bauzeitung" of Dec. 3, 1910. It is shown in the diagrammatic drawing herewith, reproduced from that journal.

The ejector comprises a hopper-bottom muck tank, a valved discharge pipe leading from the bottom of the tank to the open air, a valved auxiliary air pipe leading into the discharge pipe at an acute angle, and a water pipe for furnishing water to keep the contents of the tank in fluid condition. The tank is made in sections so as to permit taking it through the air-lock. The discharge pipe as used was of 3½-in. diameter, the auxiliary air pipe 2-in.; the latter pipe joins the discharge pipe at a forward angle



MUCK EJECTOR USED IN FOUNDATION CAISSON AT AARAU, SWITZERLAND.

of about 45°. The compressor supply is at fairly high pressure, being used also for operating pneumatic hammers; the caisson supply is taken through a reducing valve. The auxiliary air is taken at the high pressure.

In operation, the tank is filled with muck, and if this is clayey in nature sufficient water is added to enable it to be blown out; sand is handled without water addition. The discharge valve being kept closed, the auxiliary air valve is opened, producing a strong ejector action in the discharge pipe. Then the discharge valve is opened, and the muck is blown out very rapidly. The tank is kept constantly supplied by shovelers; whenever the tank becomes nearly empty the discharge valve must be closed at once, to prevent serious loss of air from the caisson.

The working principle of the apparatus is that the caisson pressure is utilized only to force the material far enough for the ejector action of the auxiliary air to take hold of it; the latter then does the main part of the lifting. Thus it was possible to blow muck from a depth of only 7 to 10 ft., whereas with the simple blow-pipe a depth of over 30 ft., i. e., a pressure of about 15 lbs., had to be reached before muck could be handled in this way

The drawing shows also the form of reinforced-concrete caisson used in the Aarau work. Caisson chambers of this material are finding increasing use in European practice; the inner face is sometimes stepped instead of inclined.

Improvement of Port Facilities at Kobe Harbor, Japan.

By H. McL. HARDING,* Assoc. Am. Inst. Elec. E.

Many of the European harbor terminals have been built and equipped for a number of years, and much that we see when we visit these ports would not be duplicated by the engineers who formerly constructed them, if they were to design new works to-day for the same harbors. It has been regretted by eminent engineers that the world-famed quays and docks at certain English ports have been so massively constructed, on account of the present great difficulties in making desired and necessary improvements, due to changed conditions of traffic and the increased size of ocean steamships.

Kobe, Japan, is a long distance from Hamburg and Liverpool, the two most important ports of Europe, but the Japanese have in Kobe adopted the most advanced methods of quay and pier construction for their leading export and import city. The export and import tonnage of Kobe for the last year was 2,200,000 tons against 1,600,000 tons for Yokohama.

A half century ago the seaport of Kobe was a lonely fishing hamlet. In 1867 it was opened to foreign trade, and in the following year four landing places and three warehouses were constructed. From 1873 to 1901 sheds and warehouses were added until in 1901 there were eight warehouses covering 20,550 sq. ft. and fourteen sheds with 165,852 sq. ft.

The freight handling equipment early consisted of nine cranes of 5 to 30 tons capacity. There were then five small piers, one being private property. Other piers and sheds were gradually provided and a safe moorage for lighters was secured by two breakwaters, one upon the east and one upon the west.

In 1907 it was decided to reclaim the seafront, build longer and wider piers and extend the accommodations on shore, the work to be finished in ten years. The work has now been in progress three years.

One detail of the harbor work, the building and placing in position of the reinforced-concrete caissons, for the piers, is of special interest to engineers. Each caisson is 119 ft. long, 35½ ft. high, 24 ft. wide at the top, and 34 ft. wide at the bottom. The reinforcement is of iron bars one-half or three-fourths inch in diameter. Each caisson is divided into 20 compartments, 10 on each side of a concrete partition which runs through the center of the caisson. A completed caisson weighs 1,900 tons.

In moving the caisson into place a kind of floating dock is brought alongside the construction pier, and a portion of this dock is passed underneath the caisson, so that when the water is pumped out of the dock, the caisson is lifted off its supports. The dock is then moved away from the pier and again sunk, leaving the caisson floating. The caisson is then towed into position, filled with water and sunk to the bottom.

The wells in the caisson are then filled with concrete and sand, which, in due course, forms one solid mass weighing 5,500 tons. Ten of these caissons will form one pier.

The general plan of the harbor works is as follows: The reclaimed foreshore will extend from the point of the headland on the east towards the west, the sea having a uniform depth of water of about 20 ft. at this part. A sea wall and quays or piers will be constructed upon the reclaimed ground; foreshore walls and landing stages will also be provided. The total area of the reclaimed ground will be about 2,880,000 sq. ft. Its height will be 11 feet above the mean low-water level.

The total length of the quay walls will be 9,553 ft., the length available for loading and unloading being 8,412 ft. Assuming that on each six feet of the quay 1,500 tons of cargo can be handled in a year, the total accommodations of the quay for landing and discharging will be 2,100,000 tons per annum. Nineteen steamers, representing a total tonnage of about 134,000 tons, can be moored alongside the quay walls at one time.

Landing stages, 1,797 ft. long altogether will be set up, one at the northwestern corner and two others at the foreshore of the reclaimed ground, and will be available for the loading and unloading of lighters with a draft not exceeding 9 ft. The walls of the remaining foreshore of the reclaimed ground will be available for mooring steam launches with a draft of about 9 ft. A sea-wall projecting from the eastern end of the reclaimed ground will be about 2,400 feet in length and its top will be from 16 to 20 feet above low-water level.

The sheds to be erected are of two classes, one for cargo dealt with on quays, made of iron, and the other for cargo dealt with at the landing stage, made of wood. The iron sheds will cover an area of 602,640 sq. ft. of ground, and will be placed at a distance of about 20 ft. from and parallel with the quay walls.

Between the sheds and quay walls, lines of rails will be laid down for the transit of goods which do not require the sheds. In addition, a line of rails (wide gage) will be constructed for the traveling cranes, with the smaller rails between. Behind the sheds there will be constructed another line of rails for the conveyance of goods to and from the sheds.

Transferring Machinery.

Stationary and traveling cranes will be used on the quays, and are to be worked by electric power generated in the compound. The stationary cranes will be of 30 to 50 ton capacities. The traveling cranes may be moved to any point required, and will be used for discharging and loading direct from and to steamers, the lifting capacity ranging from 1½ to 5 tons.

The total number of cranes will be 59, comprising 2 stationary cranes; 52 traveling cranes; and 5 hand-power cranes and, in addition, one of 30 tons and the other of 5 tons lifting power for the landing stage. In addition to the cranes, over 50 capstans, all operated by electric power, will be provided for mooring vessels and moving goods trucks.

The gantry cranes are well adapted to transferring the cargoes between the ships and the cars, between the sheds and vessels, or the nearby sides of the piers and quays. If the cargoes are to be conveyed to and from the sheds and warehouses, then by the proposed plans there must be one or more rehandlings with additional expense and the accompanying loss from breakage and thefts. At the time the plans were made, the gantry crane was considered the most efficient type.

Should, however, the latest modified traveling cranes be installed with a number of electric transfers in the place of the gantry and fixed cranes, then the cargoes could be transferred from any one of a ship's hatchways to cars located anywhere on the tracks, or into any of

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the sheds, or to any portion of the compound, or even to the warehouses, all without any rehandling, serving areas, including tiering, also without rehandling, and with a continuous rapidity of unit movements, without congestion or interference. There would be produced not only economical transference, but also a great reduction in the time of discharging and loading. This would enable not merely 250 tons for each foot of quay length to be handled yearly, but from 375 to 500 tons per lineal foot. This requires no new types of machinery, but a better engineering adaptation and combination of the existing mechanism which has been long in operation.

It will be noticed that at Kobe, as well as at all other important ports abroad, the cargo handling machinery is to be purchased and installed by the government. At all other important foreign ports, the different governments have realized that no other investment in harbor improvements could produce as much return in developing commerce, as improved machinery.

This important fact does not yet seem to be appreciated by the Federal, State or City Governments of the United States, and therefore little or no machinery is installed, even on piers owned by the public. It is not sufficient for the State or local authorities to build substantial piers, but they should be equipped with machinery able to move cargoes any reasonable distance from the ship's side without rehandling. On account of the State or City authorities in the United States not realizing this, and not equipping their piers with machinery, manual labor with its great expense, is still retained at most American ports.

The magnificent Commonwealth Pier in Boston is an example of a fine pier never used to but a fraction of its capacity, on account of lack of freight transferring equipment to attract vessels and also because it has no proper connection with the rear land or with the railways. Abroad it is considered as necessary for the government to thus equip the piers as to build them.

Until such equipment is provided, it will not be possible for the terminal charges on freight commerce at United States ports to be as low as that of its foreign competitors for the world's trade. Not only can we learn the above lesson from Japan, but also that the water front with its piers, bulkheads and equipment should be not only owned but controlled by the public authorities, and all terminals should be under the direct charge of joint boards appointed by the State and City.

Locomotive Smoke in Chicago.*

By PAUL B. BIRD.†

Chicago is one of the greatest railway and manufacturing centers in the world. Soft coal from Illinois and Indiana is the universal fuel used to carry on this industrial activity, but as this coal is difficult to burn without making smoke, the result has been to defile the atmosphere with great quantities of smoke and dirt. To reduce this condition to a minimum is one of the problems confronting the engineers of Chicago.

For years it has been an open question as to how much of the total smoke of Chicago is made by locomotives. It is often stated that they make a very small proportion of the total smoke, and that from a standpoint of smoke prevention the electrification of railway terminals is unwarranted. During the last few months the Department of Smoke Inspection has made an investigation to determine the proportion of the total smoke made by the railways. The results of this study may be summarized as follows:

1. Although the locomotives of the city use only 18½% of the total coal, they make 43% of the total smoke and over 50% of the total dirt.

2. Because smoke from locomotives carries large quantities of sparks and cinders, such smoke is a greater dirt producer than smoke from stationary plants.

3. The locomotives consume, within the city limits, 5,600 tons of soft coal daily, or about 1,850,000 tons annually.

4. According to the Ringlemann system of judging the density or blackness of smoke, the average density of locomotive smoke in Chicago is 23%.

5. The lowest average density of smoke produced by any one road is about 10%. This probably represents as low an average as can be maintained with steam locomotives, using soft coal.

6. If all locomotives in Chicago maintained an average smoke density as low as 10%, the locomotive smoke would still form 29% of the total smoke and probably produce over 33% of the dirt.

7. Locomotives in neighboring towns make an average smoke density of about 41%, showing that the anti-smoke campaign in the city has already reduced the smoke nearly 50%.

8. Approximately 10% of all coal fired in a locomotive firebox is discharged from the stack in the form of cinders. Within the city limits of Chicago about 560 tons (14 carloads) of cinders from locomotive smokestacks are dropped every day.

9. There are about 2,200 miles of railway track in the city limits. At all times there are about 1,400 different locomotives working in the city, and during a week as many as 3,740 different locomotives are in Chicago.

As smoke is caused chiefly by the incomplete combustion of bituminous coal, the basis of this investigation is a study of the coal consumption of the city. The Smoke Department gives as its opinion that there are burned in the city limits annually 10,000,000 tons (2,000 lbs.) of bituminous coal. This figure may be taken for the year 1910 and to include semi-bituminous or Pocahontas coal (1,000,000 to 1,200,000 tons). The consumers are classified as follows:

1. Central district (bounded by Chicago Ave., Halsted St., 22d St. and the lake). This includes boiler plants of office buildings, hotels, wholesale buildings, factories, etc. Annual consumption, 1,125,000 tons of soft coal and 375,000 tons of semi-bituminous coal.

2. Miscellaneous power plants, including all stationary high-pressure boilers outside of the central district. There are about 7,000 such boilers in the city; the average boiler HP. is 143 HP., and the average load is about 75% of the installed boiler capacity. Annual consumption, 4,500,000 tons (or 5,625,000), including the boilers in the central district.

3. Flats and family hotels, with low-pressure steam-heating plants. These consume 750,000 tons annually, most of this being Pocahontas coal.

4. Domestic heating; residences and small flats using coal mainly in stoves, 650,000 tons.

5. Special furnaces for heating, melting, annealing, etc., in industrial plants, 600,000 tons.

6. Locomotives. Returns show a daily average of 5,600 tons, and 33% of this is assumed for Sundays (holidays assumed to be the same as week-days), 1,850,000 tons.

7. Steamboats (including freight and passenger boats, tugs, dredges, pile drivers, etc.), 150,000 tons.

COAL CONSUMPTION AND SMOKE IN CHICAGO.

Class.	Annual coal consumption, Tons.	Annual coal consumption, P. ct.	Smoke—Amount. P. ct.	Smoke—Density. P. ct.
1. Central district	1,500,000	15.0	6.0	3.75
2. Miscel. power plants	4,500,000	45.0	30.0	6.50
3. Flats	750,000	7.5	2.5	3.00
4. Domestic	650,000	6.5	2.0	3.00
5. Special furnaces	600,000	6.0	12.5	20.00
6. Railroads	1,850,000	18.5	43.0	22.30
7. Boats	150,000	1.5	4.0	25.00
	10,000,000	100.0	100.0	

During October and November, 1910, a special observer spent his entire time on the rights of way of the railways in the city limits. He made over 11,000 observations and watched the locomotives of 30 different railway companies. He was assigned each day to a certain point on some road, often at a junction of two or more roads, his instructions being to watch every locomotive and to record in his memorandum book the number of minutes during which he watched the engine and his estimate of the density of the smoke in accordance with the Ringelmann charts.

The record shows that the dirtiest place in Chicago was at 55th St and the C. & W. I. Ry. tracks. This point is also at the south end of the Erie Ry. yards. The average density obtained on this day (Oct. 20) was 45.4%. Similarly, this list shows that the cleanest place was at the Illinois Central Ry. tracks and Van Buren St., where the average density was 10.5% on Oct. 10. The locomotives of the Wisconsin Central Ry. (leased by the M., St. P., & S. S. M. Ry.) occupy first place with an average density of smoke of 10.76%. The Chicago Junction Ry. occupies the lowest position, with an average of nearly 42%. The average percentage of locomotive smoke density in the two months' investigation is 22.3%.

During December, 1910, the same observer was sent to eight outside towns to make similar observations. The density of smoke averaged 41%. This is probably a fair figure for the performance of a locomotive using Illinois or Indiana coal with no particular attention paid to preventing smoke. Streator, Ill., had the smokiest locomotives, 361 observations averaging 51% smoke density. This indicates the results of the anti-smoke campaign in Chicago. It shows that outside of the city, where no effort is made to prevent it, the smoke is nearly twice as dense as in Chicago. This is true of the stationary plants as well as the railways.

Locomotive smoke carries with it quantities of sparks and cinders, while in stationary plants relatively little of such material is thrown out. This is because of inherent features in the design and working of the locomotive: the small grate surface and the powerful draft. It is recognized among railway men that from 8 to 18% of all bituminous coal put into locomotive fireboxes escapes from the stack in this manner. In Chicago about 5,600 tons of coal are burned in locomotives each day. Assuming that 10% of the coal leaves the stack in the form of cinders, it means that 560 tons of cinders are thrown into the air and dropped on the city of Chicago every day.

The lowest percentage of smoke density made by the locomotives of any railway was 10.7%. Probably 10% is as low an average as can be maintained with steam locomotives using soft coal. Therefore the very best condition that can be hoped for in Chicago is to have all locomotives average 10% density, which would mean that the locomotive smoke would still be 29% of the total, and probably be responsible for over 33% of the dirt. The modern steam locomotive is such a highly developed machine that it is unlikely that any change will be made in its construction which will produce better results than this. A further reduction of the smoke made by locomotives can only be brought about by change of fuel. The possible fuels besides the local soft coals are: (1) semi-bituminous coal, (2) anthracite coal, (3) coke, and (4) oil.

A considerable amount of semi-bituminous or Pocahontas coal is now being burned by some of the railways in Chicago, and although it makes less smoke than Illinois coal under the same conditions, its use by no means guarantees the entire elimination of smoke. Probably the universal use of semi-bituminous coal would not succeed in reducing the average density of smoke below a point that is considered possible with Illinois coal. The general use of anthracite coal or of coke for locomotives would eliminate smoke, but the other nuisances due to steam locomotives would not be diminished. If coke were used there would be an increase in the quantity of sparks and cinders discharged. In either case the volume of furnace gases and their effect in vitiating the atmosphere would not be reduced. Fuel oil makes smoke unless carefully handled, and the smoke that is made is more objectionable than the smoke from soft coal. It is probable that if all locomotives in the city burned oil, the smoke and gases would form more of a nuisance than the soft-coal smoke of to-day.

The general use of any special fuel would greatly increase the cost of fuel to the railways, and the practical difficulties involved would make it a very difficult thing to bring about. The locomotive fireboxes would have to be changed if coke or hard coal were used. In order to ensure that all locomotives operating in the city limits used the same fuel, all the engines on an entire division would have to be thus equipped, which would greatly increase the cost of operation.

The study that has been made along these lines indicates clearly that electrification offers the only final and satisfactory solution of the locomotive smoke problem. The use of special fuel for preventing smoke on steam locomotives is only a makeshift and will not satisfy the public.

*Abstract of a paper read before the Western Society of Engineers, Chicago, Feb. 15, 1911.
†Chief Smoke Inspector, Chicago, Ill.

CAST-IRON CAR-WHEEL DESIGN was referred to before the Western Railway Club in discussing a paper by W. S. Killam, of the Griffith Wheel Co., entitled "Standardization of Chilled Iron Car Wheels, with Reference to Service Conditions." The paper contained a table of required thickness of plate or web of the wheel for various loads and for various brake-shoe pressures, and also a table of wheel weight for various plate thicknesses. In explanation of these tables Mr. F. K. Vial, of the same company, stated that they were based on the following formula:

$$\text{Plate thickness} = \sqrt{\frac{\text{Gross load}}{300{,}000}} + \frac{\text{Brake pressure per car}}{80{,}000}$$

The derivation was empirical; it is assumed to hold for various diameters from 24-in. to 36-in. The two underlying assumptions are: (1) That both the cross-breaking strength and the load-bearing strength of the wheel increase as the square of the plate thickness; and (2) that heating from brake application is proportional to brake pressure, and resistance to thermal stresses is proportional to plate thickness. The metal required for thermal stresses was added to that required for load carrying. The constants in the formula were fixed after observing many wheels as they came out of service, and observing wheel action on mountain grades. The thicknesses given by the formula are said to correspond well to the weights of wheels adopted as standard by the Master Car Builders' Association. The tread thicknesses used with the wheels designed by this formula vary from 1½ ins. to 2½ ins., and the wheels of 33-in. size range from 550 lbs. (for cars up to 60,000 lbs. gross load on eight wheels, lighter cars than commonly used) up to 900 lbs. (for cars of 200,000 lbs. gross load on eight wheels).

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One of the speakers at the Pan-American Commercial Congress held at Washington last month, resurrected the corpse of that dead and buried project, the Intercontinental Ry. Many of our older readers will recall that some Government money was spent on preliminary surveys for that proposed railway nearly a score of years ago, and it was found that the profile of the line through a considerable part of Central and South America along the Andes resembled the teeth of a cross-cut saw.

The project never attracted serious attention from capitalists because it was clearly evident that the cost of carrying either freight or passengers between North and South America by rail, would be far more than freights or fares by ocean steamers, even without including the interest on the enormous cost of building the road.

Doubtless with advancing civilization and more stable government in Central and South America, a considerable part of the Intercontinental Ry. will be constructed as independent links for local transportation. But both topography and economic considerations dictate that South American railway construction shall proceed on radial lines from its principal seaports, and such lines are not well adapted to be joined up for through transportation.

Another long-buried project was also resuscitated and trotted forth for public inspection last month, the project for creating a great freight and passenger terminal for ocean steamships at Montauk Point, on the eastern end of Long Island.

The public exhibition of ghosts is chiefly useful to frighten people. It is suspected that the Montauk Point specter was conjured up to frighten New Yorkers into the belief that commerce would forsake this port if permission is not given to extend the pierhead line on the North River water front, so that the four new record-breaking vessels which the White Star, the Hamburg-American and the Cunard companies are building may be docked there.

We doubt, however, whether the ghost will really frighten sensible people. It is pretty clear that the apparition is only an artificial sheet and pillow case affair. Suppose all the many millions of dollars necessary were expended on the eastern end of Long Island in the creation of docks, piers, railway terminals, shops and warehouses, and a city to house the army of workers required to carry on all these appurtenances. Suppose all this were done, could freight or passengers be handled more economically through such a port than through New York? It is evident that the transportation itself would be more expensive. To shorten by about a hundred miles distance and four to five hours time, the transatlantic passage reduces the cost of the steamer's voyage only a very small amount. On the opposite side, however, is the added cost of 100 miles of rail haul, and what is more important still, the added cost in many cases of extra handling or transfer of freight, freight cars or passengers.

The only way in which the proposed port could effect a saving in total transportation cost would be by reducing the terminal expenses over those now prevailing at New York City. It is not easy to see how even this could be done. Railway freight to or from Long Island would still have to pass through the crowded terminals of New York City and would have to be transferred by water from the mainland to Long Island.

Again at the present day it is impossible to carry on transportation business economically on a small scale. The Montauk terminal would have to be capable of handling a large volume of traffic and the plant there would represent a huge outlay. The interest and maintenance charges on this outlay would amount to a large sum per annum which must in one way or other be assessed upon the commerce passing through this port. It would probably be found that at best the necessary expenses via the Montauk Point route would be as great as or greater than the commercial routes via the ports of Boston or Philadelphia or Baltimore or Norfolk.

A recent trade publication, issued by the Colorado Portland Cement Co., exploiting the use of a certain "alkali-proof" cement which that company is manufacturing, contains on one of its pages a line drawing, neither dimensioned nor scaled, showing the section of a concrete gravity dam, with only about one-fifth of the base resting on the "Bed-Rock?" foundation, the remaining four-fifths being occupied with a large empty space marked "cavity." Accompanying the drawing is the following caption:

AN EXAMPLE OF DISINTEGRATION.

Tansil Dam, Pecos Valley, N. M.—About 40 feet high by a quarter of a mile long. Is practically eaten up by alkali; all except two inches of the surface is soft or entirely disintegrated after 6 years. Part "B" was built about two years ago, under the direction of U. S. Reclamation Service Engineers and is also totally destroyed by alkali. A man can walk in water the entire length of the dam on the bedrock in the space from which the decomposed concrete has been washed.

We are reliably informed that these statements are incorrect; that the dimensions of the dam as given are wrong; that there is no proof that the failure is due to alkali, and that the Reclamation Service has had nothing whatsoever to do with the work.

The Tansil Dam is but 600 ft. long and 23 ft. high. It is a concrete dam founded on gypsum rock formation and built largely of a gypsum rock aggregate. It does show a pronounced disintegration, possibly due to the action of an alkali water on the gypsum rock but more likely due to inferior construction and poor material. No engineer of the Reclamation Service has had anything to do with the construction of the dam. There is a report based entirely on the talk of workmen, that some two years ago some additions to the dam were made, "under the direction of an officer of the Reclamation Service," but there is no record in that Service that any officer was so employed, nor is there any knowledge of the performance of such work by any government engineer acting in a private capacity.

In justice to the company publishing this pamphlet, it should be said that it, too, has become convinced of the incorrectness of the statements referred to and has destroyed the remaining copies of its pamphlet and issued another with this page removed.

Inasmuch as the pamphlet had some circulation and incidentally as the cut with a portion of the attached caption was reproduced in a western mining journal, it is only fair to the Reclamation Service and to those who are studying the effect of alkali on concrete that the error should be here publicly corrected. Possibly the cavities in the Tansil Dam may be due to alkali water, but before any lesson can be drawn from the example a thorough study of the nature of the water and the conditions of erection and material of the dam should be made.

That the only remedy for the smoke nuisance in Chicago is the electrification of the railway lines within the city limits is the conclusion reached by the City Smoke Inspector, Mr. Paul P. Bird, in a paper read before the Western Society of Engineers last week. An abstract of this paper is given elsewhere in this issue. Its main conclusions are as follows: (1) locomotives in the city account for about one-fifth of the total coal consumption, but make nearly half of the total amount of smoke and more than half of the dirt due to smoke; (2) these conditions cannot be improved, even with the most thorough inspection and careful firing, so that the smoke and dirt will be less than about one-third of the total; (3) there is very little room for improvement in the way of alterations in locomotive construction, or in the use of special fuels (anthracite coal, coke or oil). On this basis it is declared that the only satisfactory solution of the locomotive smoke problem is the adoption of electric traction by the various railways.

Mr. Bird makes no reference, however, to the great economic question involved in electrification. Will the enormous expenditure necessary for converting all the railway lines in Chicago to electric traction be justified in order to eliminate half or a third of the smoke in the city?

Of course the public, which thinks the cost of railway electrification is to come out of the railway treasuries, is vociferous for electrification. It does not stop to think that in the end the cost of electrification must be paid for by the people of Chicago.

Here is an object lesson on that very point. The commuters travelling on the New York, New Haven & Hartford R. R., are appealing to the Interstate Commerce Commission for relief from the large advance in suburban passenger fares made by that company a year ago. The railway company replies, however, that the added cost of electric operation and of the new passenger terminals, is so great that it has to advance its rates in order to make the traffic pay the actual cost of handling.

As a State Commission in Massachusetts has recently well said, electrical operation of steam railway terminals is an expensive luxury. Cities have to go without many luxuries which they would like to enjoy.

Chicago is in need to-day of many improvements which cannot be classed as luxuries. Its water supply, for instance, is sadly deficient in some respects (in certain sections water cannot be obtained in the upper floors of houses), and there is demand for a much better fire protection supply. Street paving and street cleaning on a scale and in a manner adapted to the importance of the city are urgently needed, and there is great need also of the long-projected subway system to improve rapid transit conditions. But to demands for these and many other needed improvements the city makes the reply that it has not and cannot get the necessary funds for them all and that the only thing to do is to select those which are most important and proceed with one improvement after another as rapidly as funds can be obtained.

Now, as everyone knows who has given study to the subject, the same principles ought to govern railway financing whether the railways are owned by private companies or by the Government. In either case, the public must in the long run pay all the cost of their operation and the interest on the capital invested. If the railways are forced to spend money for extravagant methods of operating, the travellers and shippers and the ultimate consumers must foot the final bill for the extravagance.

The Interstate Commerce Commission has just refused the request of the railways to sanction a

horizontal increase in freight rates and has based its refusal on the ground that present railway profits are fairly compensatory. But suppose Chicago and Boston should compel electrification of all the railways within their borders. Nothing is more certain than that half a dozen or a dozen other cities would make a similar demand. Where could money be found for such needed improvements as grade-crossing elimination, safer signaling, double-tracking, improvement of freight terminals, steel cars, more permanent track and bridges, if many hundreds of millions must be laid out in electrifying terminal lines in cities?

We believe the question is far broader than the interests of Chicago alone or Boston alone; and that it ought to be studied from a broad and unprejudiced standpoint.

The Passing of the Waterway Boom.

Three significant events have occurred during the past week which have an important bearing on the question of waterway development.

The first was the announcement by the Lehigh Valley R. R. Co. that it wishes to abandon the old Morris Canal across New Jersey. The figures of earnings and expenses made public by the company show that this waterway, one of the very few remaining examples of the old time barge canal, was never a financial success even in its best days.

The second event was the report of the special Board of Engineers on that section of the proposed "Lakes to the Gulf deep waterway" extending across the State of Illinois and joining Lake Michigan with the Mississippi River. This report demonstrates the absurdity of the popular agitation a few years ago for "Fourteen feet through the Valley" and the almost equal absurdity of the project to bring ocean vessels up the Mississippi River to St. Louis and Chicago.

The third was the decision of the Interstate Commerce Commission denying the petition of the railway companies for permission to make a horizontal increase in freight rates. The stock argument of waterway advocates has long been that inland waterways were worth while because their competition would keep down railway rates. The Interstate Commerce Commission's decision is a demonstration that railway rates can be controlled directly.

It seems to us that each of these events deserves a few words of comment.

Taking up first the Morris Canal, this was one of the four notable canals built in the first half of the last century to carry the product of the anthracite coal field to market. The other three were the Delaware & Hudson Canal in New York, the Schuylkill Canal and the Lehigh Canal in Pennsylvania. Of these the first was abandoned in 1898, its owners finding that the cost of operation was so great that it was cheaper to transport their coal by rail. The canal had ceased to pay interest on the money invested in its construction long before. The locks and dams on the Schuylkill River, once used by coal boats, were abandoned at an even earlier date. The Lehigh Canal alone remains in operation.

Of these four canals, the Morris Canal furnished a direct route across New Jersey to the market of New York City. Without doubt its original promoters had high hopes for its financial success. When it was chartered, in 1824, canal building in the United States was at its height. The Erie Canal was about half completed and other canals were projected or under construction in Massachusetts, Pennsylvania, Virginia and Ohio. Everyone could see that the canal was a great improvement as a freight carrier over the turnpike road and the freight wagon. The railway was a new invention only beginning to be talked about and only conceived of as a competitor of the stage coach for high-speed transportation. It was nearly a generation after the railway era began before it was perceived, even by railway engineers, that the railway wes destined to be the future system for economic freight transport as well.

The Morris Canal had great topographic difficulties to overcome. In passing from the Delaware River at Easton to the Hudson at Jersey City it had to pass over an elevation of 900 ft. In the total length of the canal, 107 miles, there were 22 incline planes and 30 locks. The marvel is that notwithstanding these difficulties the canal was built for the very moderate sum of between five and six million dollars. With all the advantage of modern machinery, it probably could not be constructed at the present day, with present prices of labor and material, for such a sum.

Notwithstanding its economical construction the canal was never financially successful. It paid dividends only in the years from 1852 to 1866, but some of these dividends were in scrip and not in cash. In the memorial just presented to the New Jersey legislature it is said:

> The reason for the canal's financial failure is quite plain. While the charter was being passed, George Stephenson was perfecting the invention of a locomotive, and the Stockton & Darlington railroad in England was opened, with steam transportation, nine months after the canal was chartered. The Morris & Essex R. R., paralleling the canal from end to end, was chartered in 1835, one year before the canal was opened to Jersey City.
>
> Within ten years after the chartering of the canal the bright expectations with which the charter had been taken began to be disappointed by this new and better method of transportation. The directors' annual reports show the constantly growing stress of this competition. After steel rails were put in use in the '60's, the Lackawanna R. R. completed through to tidewater, and the Central R. R. of New Jersey built, freights fell to a point which made navigation on the canal perfectly hopeless.
>
> When it is remembered that the largest boat on the canal carries but 70 tons and consists of two sections, which must be separated at 22 different inclined planes and pass through more than 30 locks to get over the mountains from the Delaware to the Hudson, and that the journey occupies five days, while a single locomotive will take 2,000 tons of coal over the same trip in five hours—the result of such competition is perfectly obvious.

Each of the three railways which parallel the canal have a carrying capacity of not less than ten million tons per annum and they operate the year round. The canal was originally designed for a capacity of a million tons. In 1866, its year of heaviest traffic, it carried under 890,000 tons. Its operation is suspended during at least four months of the year.

By 1877 the gross earnings of the canal had fallen below the operating expenses, and it would have been abandoned a quarter century ago except that the water rights in connection with it were supposed at that time to be valuable. As it is, for fully a score of years the traffic upon the canal has been so trifling in amount that the canal may be said to have been practically abandoned as a transportation route long ago.

Turning now to the Illinois section of the Lakes-to-the-Gulf waterway, the Board of Engineers in its report upon this project gives what ought to be a final quietus to the theory which has been so widely circulated, that great depth is essential to economical transportation on an inland waterway. The Board shows that for river navigation the barge drawing not more than 8½ ft. of water, and with a capacity up to 3,000 tons, is as economical a freight carrier as any vessel afloat. Channels with a depth of 8 to 9 ft. are sufficient for such barges and are therefore more economical avenues for freight transport than deeper channels, since the greatly increased cost of deeper channels burdens the traffic with a larger fixed charge on the investment.

There would be no gain whatever, the Board shows, in increasing the depth of the channel to 14 ft., since such a channel would not be deep enough for either lake or ocean vessels. In order to accommodate these, at least 24 ft. depth would be essential and the cost of a channel of such depth through the Mississippi Valley, the Board says, would be enormous. Even if a 24 ft. deep waterway were constructed, however, it would not be used by deep draft vessels since traffic could be handled at lower expense by light draft barges.

We do not believe it will be possible to break the force of this clear, logical presentation by expert authority of the foundation facts respecting the economics of inland transportation. The engineers who make this report, like the engineers who have made other reports of the same tenor, have absolutely nothing to gain by making this stand against the current agitation for huge expenditures on waterways. On the contrary, a certain amount of business would be furnished to engineers and contractors by large Government appropriations for deep waterway construction.

The latter, however, is a narrow point of view which cannot be justified by any code of professional ethics. In the long run the engineering profession suffers inevitably when works which are carried out by its advice prove financial failures. Money expended in work which proves useless or unprofitable is as truly a waste and loss to the community as loss by fire or flood or tempest. It is as much a part of the engineer's business to conserve capital as to conserve natural resources.

It is worth especial notice also that the Board recognizes that the question whether *any* type of inland waterway can successfully compete with rail transport is still an open one. The Board says:

> Considered as a business investment, a waterway of even moderate depth from Chicago to the Gulf is still more or less experimental.

The facts abundantly justify this statement. There is already maintained from the Lakes to the Gulf a channel at least 9 ft. deep at low water from New Orleans to Cairo, 8 ft. deep from Cairo to St. Louis and at least 4½ ft. deep from St. Louis to Chicago. Yet the traffic of this waterway (except on the lower part where coal boats come down from the Ohio) is insignificant.

The current idea is that the steamboats have disappeared from these waters because of lack of depth; yet the present depth of the Mississippi is much more favorable to traffic than the depth of the River Rhine, which has an annual traffic of over 54,000,000 tons, far greater than that of any other river in the world.

Considering these facts with an unprejudiced mind, it certainly appears that German experience with inland waterways is not necessarily a proof of what we can expect here. The Board of Engineers submits what amounts to a demonstration that a channel of moderate depth is as favorable for traffic as a deeper and much more expensive channel, and then very pertinently says:

> As a channel of 8 ft. depth is now maintained from Cairo to St. Louis, and can be extended from St. Louis to Utica, Ill., at relatively small cost, business caution dictates that a waterway of this depth be obtained and tested before entering upon enormously expensive projects of questionable utility.

We need take comparatively little space to discuss the Interstate Commerce Commission's decision of last week. From one point of view it has no bearing on the waterway question, for the power of the Government, State or Federal, to control railway rates has been well established for more than a quarter of a century.

This present decision, however, and the public prominence given to it, comes as an object lesson to the public generally, demonstrating that it is unnecessary to spend millions of dollars on waterway construction in order to secure fair railway rates. Further than this it is clearly demonstrated that division of traffic between railways and competing waterways, wherever the railways are able to handle the whole business satisfactorily, results in higher railway rates in the long run.

The Interstate Commerce Commission refused its assent to an increase in freight rates because statistics showed that present railway profits were satisfactory as compared with former years. But railway profits depend on volume of business more than anything else. Divert any considerable percentage of present railway traffic to waterways and there would be a serious falling off in net earnings that might be held to justify an advance in the railway rates.

But the principle is even broader than this. It applies to the needless duplication of railway lines by competing companies. No manufacturer would buy two or three huge expensive machines for his mill when a single machine was capable of handling the entire output with a large margin to spare. No more should the public sanction the waste of capital involved in the needless duplication of transportation lines, whether that duplication be by railway or waterway.

LETTERS TO THE EDITOR.

Standard Sizes for Trade Catalogs.

Sir: For a number of years the writer has been an earnest advocate of a uniform or standard size for catalogs, specifications, blank forms, letter heads, etc. The suggested size was 8 × 10½ ins., which gives four pages when cut from a standard sheet 16 × 21 ins. This size is largely used by many departments of the state of New York, as well as by many private parties.

It is a matter of congratulation to note that some progress is being made in this matter, as witness the special catalog just issued by a prominent manufacturer of filing devices, which it calls "Standardized Filing Equipment in Wood and Steel for Engineers, Architects and Contractors."

The "Vertical Filing System" is doing more to bring about desired uniformity in size (not sizes) than any other.

The style of specifications still in vogue in many quarters is that known as legal size, copied from our friends the lawyers. Nothing more inconvenient could have been invented. Imagine if our books were so printed that the leaves had to be turned towards the top.

Referring to your editorial on page 106, issue of Jan. 26, 1911, "Why not introduce Efficiency Engineering in our Law Shops?" This would be a good time to get away from this awkward legal cap size and let engineers use something convenient, logical and sensible.

In this connection it might be well to state here that a prominent firm of Buffalo lawyers uses sheets 8 × 10½ ins. for transcribing testimony, perforating them in the side, not the top, and preserving them in loose leaf binders.

Cannot engineers be at least as progressive?

Yours truly,

Emile Low, M. Am. Soc. C. E.

Buffalo, N. Y., Feb. 8, 1911.

[We regret to have to differ with our correspondent in regard to Trade Catalog sizes. The standard sizes for Trade Catalogs which were adopted by a number of engineering societies and the Master Car Builders Association many years ago, are 3½ × 6 ins., 6 × 9 ins. and 9 × 12 ins. Of these, the 6 × 9 ins. is the standard size which should be followed unless it is necessary for some reason to adopt a size larger or smaller.—Ed.]

More Concerning the Federal Reclamation Work.

Sir: In your review of the work of the Reclamation Service in your issue of Feb. 2, you attempt to show that, from the financial standpoint, governmental administration has been superior to private enterprise in irrigation.

The Reclamation Service began operations nine years ago and has invested $62,000,000 on which, to date $3,000,000 revenue have been derived—a return of ½% per annum. Meanwhile, approximate interest charges at 5% for the mean time of investment amount to $13,950,000. Moreover, the $62,000,000 expended is somewhat less than one-half of the $150,000,000 estimated as the total cost of the incomplete projects in which the $62,000,000 are invested. If actual costs continue to exceed estimates, the final necessary investment will be far beyond $150,000,000.

As a private enterprise the Reclamation Service would certainly be in the hands of a receiver.

If the work is finally completed for $150,000,000, the cost per acre for the 3,900,000 acres of land reclaimed will be $50, exclusive of interest charges. Reclamation by private enterprise at the time it was superseded by the Reclamation Service had cost, according to H. M. Wilson's treatise on American irrigation, less than $9 per acre. This is comparable with the governmental cost of $325 per ton for its mail service while the express companies handle their business at a cost of only $28 per ton.

After every legitimate explanation is made the case is still overwhelmingly against the government.

President Taft's Advisory Board of Engineers finds some of the work of the Reclamation Service good and sufficient. It finds some unnecessarily expensive or questionable.

Some of the largest projects were undertaken before the water rights thereunder were determined. On this point the Board says, "It is recommended that steps be taken to secure an early adjudication of water rights on all projects where such adjudications have not yet been made, and that, pending such action, expenditures be kept within the probable rights of the United States."

Of the 3,200,000 acres of land under the Reclamation Projects 1,700,000 are lands held in private ownership, a great portion of which had prior water rights and irrigation.

In one of these projects, involving the expenditure of $9,650,000 there is practically no public domain. The valley in which this project lies has been held in private ownership and irrigated for centuries. Another project equally large, has the same history. In each case their resources and private enterprise were ample for development. In each case the government is expending the public money for the extension and enlargement of private property.

The report of the Board refers to a number of cases of this kind. For the two mentioned above, 25% of the entire reclamation fund is required. In the meantime the primary object of the Reclamation Law, viz.: the expenditure of the fund derived from the sale of the public domain in reclaiming the *arid public domain* for the creation of homes at actual cost to the homeless, is neglected.

There is nothing in the record to indicate that the admirable engineering organization and the able engineers of the Reclamation Service possess any superlative qualities or efficiency not common to the typical American engineering organization.

The character of work and results in the Reclamation Service, if good, is so in spite of the handicap of government administration. If bad, it is primarily due to the same cause, especially the political log-rolling and to the wire pulling of special interests which have diverted and perverted the expenditure of the public money to enlarging private property or enhancing its value. Much of the work of the Reclamation Service has been expended in providing improved irrigation works for private property. The government is selling bonds to carry on such work while the arid public domain lies waste.

Yours truly,

J. L. Campbell.

El Paso, Tex., Feb. 7, 1911.

[Our correspondent compares the cost per acre of irrigation work done under private enterprise before the Reclamation Act was passed and the work done under that Act. Is that a fair comparison? It is perfectly well known that a large part of the irrigation work done prior to the Reclamation Act was done by utilizing the natural flow of the streams merely and of course at a low investment cost. There came a time, however, when all the natural flow of the streams was utilized and in order to extend irrigation on a large scale it became necessary to undertake the storage of flood waters. The people of the arid region declared, and we believe with substantial truth, that the creation of great storage reservoirs on the large scale demanded for economic construction and operation was beyond the ability of private enterprise to finance. They appealed, and their representatives in Congress voiced their appeal, that the Government ought to step in and undertake the work of reclaiming these arid lands. It was clearly understood that on most of these great works a heavy interest charge during the long period of time required for construction would make it impossible for private enterprise to undertake them. But does our correspondent maintain that because of this these lands should be forever barren? Is it not worth while for the Government to forego for a few years the interest on the money invested for the sake of reclaiming these desert lands and creating prosperous homes there?

Our correspondent criticises the Reclamation Service for spending money on reclaiming lands in private ownership instead of the arid public domain; but the law made no distinction between private lands and public lands. The Executive was left free to select such locations for work as might promise greatest results in the way of public benefit regardless of the ownership of the land.

How long does he think that it would have been before private enterprise would have had the courage to undertake the Roosevelt dam or the Rio Grande dam; or the ability if undertaken to carry them to a successful issue? We say nothing—though much might be said—of the misuse of irrigation projects as a basis for fraudulent promotion schemes.

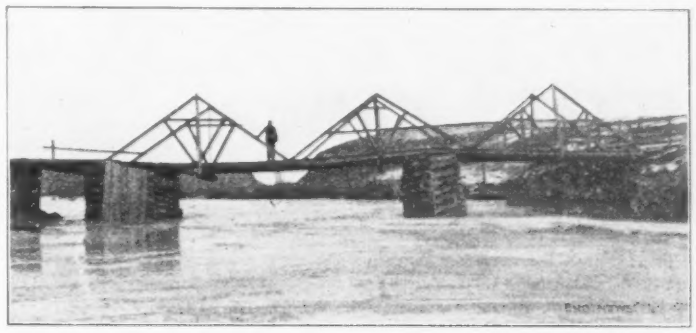
When and where an industry can be carried on by private enterprise, by all means let it be continued; but when and where private enterprise reaches its limit, the Government must step in and act for the general benefit.

In the article our correspondent refers to, we showed that changes in the law were needed to put the Reclamation Work on a better business footing. Why should not engineers like our correspondent undertake to bring about such changes? Why not do our part in leading public opinion? Why not take hold and help push instead of holding back and finding fault?

As for private enterprise in irrigation having been "superseded" by the Reclamation Service, the fact is that the 30 odd projects which the Government has undertaken are only a small fraction of the opportunities for irrigation work in the arid West. The field is open for all the private enterprise that our correspondent or any one else can muster. Further, the task of engaging private capital for irrigation work has been made easier by the wide publicity given to the work the Government is doing; and the more successful the Government's work in irrigation, the more readily can funds be raised by private irrigation companies. So we again appeal to our correspondent to quit holding back and take hold and pull.—Ed.]

A Curious Timber Bridge.

Sir: I enclose herewith an interesting and instructive photograph [reproduced herewith] of a 50-ft. highway



WOODEN BRIDGE NEAR BROWNING, MONT., DESIGNED BY BLACKFOOT INDIAN POLICEMEN.

span on the Two Medicine River, about 16 miles south of Browning, Mont. It was designed by Blackfoot Indian Policemen, and built under their supervision.

T. B. Matthews.

U. S. Indian Service, North Yakima, Wash., Jan. 29, 1911.

Objections to the "Distant Point Method" of Locating Soundings.

Sir: In the letter of Mr. James Logan, published in your issue of Feb. 2, 1911, p. 139, in which he discusses "The Distant Point Method" for locating soundings, it seems to me that the same fundamental consideration which makes questionable some of the other methods of location discussed in books on surveying applies with equal force in this case. I refer to such cases as those in which an essential portion of the method of location relies on the assumption that the sounding is being taken on some range. But as those familiar with hydrographic work know, it is frequently impossible to keep a sounding boat on a range on account of either winds or currents; yet, no matter how far a sounding boat may drift from its range, its location by supposition is always on the range. In other words, there is no *definite instrumental determination* of the position of the soundings in several of the methods that are given in the books; and it seems to the writer that no engineering investigation should be based on assumptions that are liable to a considerable error which may pass without detection.

For the above reasons the writer has always favored location by one of the following methods: intersection from two transits; by one transit on shore and a sextant in the sounding boat; or stadia locations from a point on shore. The latter method is described in such text-books as Johnson & Smith's "Theory and Practice of Surveying" (17th edition), pp. 341-2, or Patton's "Treatise on Civil Engineering," pp. 1517-18. This method has been used successfully in this country for a score of years, and it involves a considerable reduction of time and cost of field work over that mentioned in "The Distant Point Method," with no increase of expenses for office work of mapping. The stadia method, of course, simply amounts to location of soundings by

polar coordinates from one transit on shore, and so eliminates any *assumptions* for such locations. It may be stated in closing that the writer used the stadia method of locating soundings for several months, about 20 years ago, on a survey of the inland passage on the Georgia coast, a kind of survey which seems to be quite similar to that described in Mr. Logan's letter.

J. L. Van Ornum,
Professor of Civil Engineering,
Washington University.

St. Louis, Mo., Feb. 10, 1911.

Additional Information as to Quick-Dumping Ore Cars.

Sir: Mr. James S. Martin, Engineer of the Clark Car Co., in his article on the Clark ore car in your issue of Dec. 1, 1910, states that Mr. Chas. H. Clark understood the conditions to be met in the ore trade "because he had developed the Summers ore car," while in the employ of the Summers company. Such statement having been published, we feel we owe it to your readers that this false impression be corrected.

Without going into detail, we send you herewith blue prints of (1) the Summers original ore car design, made in August, 1906, and (2) the only ore car design executed by Mr. Clark for Mr. Summers while in the latter's employ. It requires but a casual glance at these two drawings to show the absence of original design or the lack of "development" of any new idea as would

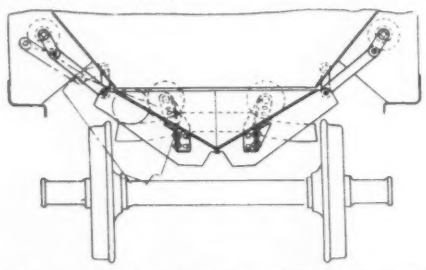


Fig. 1. Principal Features of Door Operating Mechanism of Clark Car.

be inferred from the statement above referred to. (The designs are essentially identical, and are not here reproduced.—Ed.)

Mr. Martin in his article further states that "the Clark balanced door is new in the field of dump car design." While the fact involved in this statement has not yet been passed upon by the courts, we wish to put the whole matter squarely before you, and so send a drawing of the Clark cut (as used in Mr. Martin's article) with the parts not affecting this comparison omitted, Fig. 1. Fig. 2 is reduced from a Summers tracing (out of our files) which was designed in 1903, several years prior to the so-called new Clark design of roller door, Fig. 1. It will be noticed that the general idea embodied in these two designs is identical.

In addition to this it may be of interest to note that Mr. Clark's first sample car (No 170), mentioned in some of the tests described by Mr. Martin, embodied the identical door-operating mechanism with worm gears on a transversal shaft and levers connecting to the outer end of the rolling doors as indicated in the Summers 1903 design. This first Clark car, we have learned was later on completely dismantled and many parts were used to build the present No. 210 car. It is our desire here only to completely refute Mr. Martin's statement cited above. The drawings, we think, prove our contention clearly and concisely and we wish to thus rest the matter before your readers.

If Mr. Summers had already developed the general design now used by Clark, why did he not proceed to build such a car for the ore trade? In the problem of ore transportation, the handling of ores frozen in the cars presents one of the greatest difficulties encountered. We have on record a case in the copper region where a large copper smelter was compelled to shut down on account of difficulties in handling ore frozen in cars.

In the Michigan and Missabe iron ranges the mines

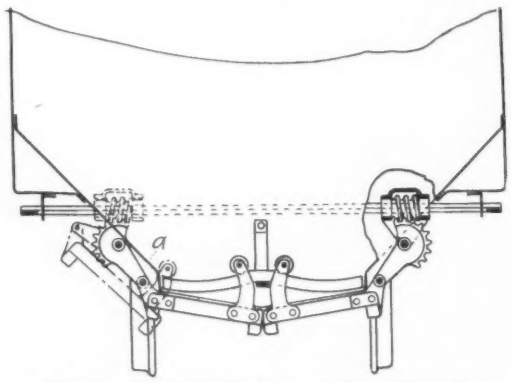


Fig. 2. Principal Features of Door Operating Mechanism of Summers Car of 1903 Design.

are situated some 60 to 80 miles from the docks and it happens frequently that ores stand in the cars over night and freeze to a depth of several inches. Ores in this condition adhere to the car sides to at least the depth frozen.

Experience has proved that in order to open doors sliding or moving in a line parallel to the lading it is necessary to resort to thawing to release the lading. The mechanical means provided for the opening of rolling doors under normal conditions prove insufficient for their operation under a lading of ore frozen thereto. On the contrary, doors weighing some 1,500 lbs., which are hinged, and thus move away from the lading, will and do open under such conditions; and experience has further proved that they dump the load. In this connection it is of interest to note that the Duluth & Iron Range Ry., a U. S. Steel Corporation road, operated Summers cars exclusively (when traffic decreased sufficiently to permit of it) during the latter part of the ore shipping season and no thawing was resorted to with these cars.

In closing, the writer begs leave to dwell briefly upon the comparative performance of the Clark car No. 210 and the Summers car; this mainly in view of the excellent showing of the former in five tests on the D., M. & N. Ry., as per Mr. Martin's article, and the fact that the roads purchased 1,500 Summers against 200 Clark cars.

The fairest and most conclusive proof of the comparative merits will be found in a series of tests performed by the Lake Superior & Ishpeming Ry., that company's test sheet being reproduced at the bottom of this page. Clark car No. 210 made 14 trips. Summers car No. 10384 made 9 trips. For each trip where the test numbers coincide the ores, etc., were alike, the different cars having been pulled in the same train from the mines to the dock. The results are self-explanatory and give for the Clark car a summary of 8.56 mins. per man per car, against 1.16 mins. per man per car for the Summers car. The Clark car recorded four failures.* These tests were made during the summer of 1909 and it is a fact that the road shortly afterward was reported to have purchased Clark cars. We are informed, however, that none of these cars are as yet delivered.

Yours very respectfully,

Frederic Schaefer.
Summers Steel Car Co.

Pittsburg, Pa., Jan. 3, 1911.

[In accordance with our usual practice we submitted the above letter to Mr. Martin and his reply is given below.—Ed.]

Sir: Mr. Clark's knowledge of handling ore resulted from his training and experience in the iron and steel industry. He was Chief Engineer of the Tennessee Coal, Iron & Railroad Co. before his association with the Summers Steel Car Co.

The general idea embodied in the design of two cars may be similar, and yet the one may be successful while the other fails. Other attempts than those referred to by Mr. Schaefer have been made to utilize the idea of a bodily moving door for dump cars, most of them antedating the date of Mr. Summers' drawings. Some of these have been patented. If dump car patents rested on general similarity in the way the doors move, Mr. Summers' patents would have little value, as many swinging doors and means for moving them were patented prior to his entering the car business. He never developed a design such as is used by the Clark Car Co.

Frozen ore in cars is difficult to dump, but it represents only a small fraction of 1% of the ore handled. Clark cars were opened under frozen loads, under the same conditions as the Summers cars, during the closing of the season last fall, and there was not (to our knowledge) a report of failure to operate. This statement is based on the word of an official having in charge the dumping of ore. Mr. Schaefer's statement to the contrary is not based on competitive tests.

In general, the Summers Steel Car Co. was in the car business prior to the Clark Car Co.; and, at the time the latter entered into competition, the development of the Summers design had been carried to the point of selling cars which had been through the experimental stage.

The Summers car used at Marquette in the Lake Superior & Ishpeming Ry. tests was one selected from 800, and was the perfected design. This car was equipped to be operated by air only. The Clark car was one hastily built in a boiler shop, and was often in bad condition through no fault of the design, all of this being recognized by the officials of the Lake Superior & Ishpeming Ry. Immediately following these tests, the L. S. & I. Ry. placed its order with the Clark Car Co. of the entire requirement of ore cars at that time, and has since entered into negotiation with this company for additional cars. This railway has not ordered any Summers cars or any other design than the Clark car for handling ore since the tests referred to were made. In view of this situation, it seems superfluous to check Mr. Schaefer's report of the L. S. & I. Ry. tests. We will note, however, that the first eight tests of the Clark car and test No. 8 of the Summers car were not in competition; and further that, throughout the time of making these tests, various changes were hastily and temporarily embodied on the Clark sample car more or less affecting its operation. Some of these features were for the purpose of reducing the length of the hopper opening to meet the length of the bins, and three of the items of comment (A, C and D, in the table) were due to temporary plates which were placed in the ends of the hopper for the purpose of shortening the opening. These plates bound on the doors of the sample car in closing.

The Clark car in addition to the hand mechanism was equipped with an air cylinder of about half the area and length of the cylinder on the Summers car. The delay of item (B) (in table) resulted from an experiment

TESTS OF QUICK-DUMPING ORE CARS.

Kind of Car.	Test Number.	Date.	Light Weight.	Weight of Ore, tons.	Number of Men Worked. Total time consumed, minutes	winding and unwinding doors.	Punching Ore.	Cleaning Cars.	Bumpers.	Total men.	Number Minutes, One Man.
Clark No. 210.	1	9/26	32,000	45	1—0	1	0	0	0	1	1—0
	2	9/27	32,000	48	0—40	1	..	..	..	1	0—40
	3	9/29	32,000	47	2—20	..	..	..	4	4	9—20
	4	9/30	32,000	40	2—05	1	..	..	..	1	2—05
	5	9/30	32,000	37	0—27	1	..	..	..	1	0—27
	6	10/2	32,000	47	4—15	1	2	2	..	5	21—15(A)
	7	10/6	32,000	50	5—20	1	2	2	..	5	26—40
	8	10/8	32,000	48	8—30	1	1	2	..	4	34—0
	2*	10/12	32,000	50	2—10	1	1	2	..	4	8—40
	3*	10/14	32,000	50	1—0	1	..	2	..	3	3—0 (B)
	4*	10/16	32,000	44	1—30	1	..	1	..	2	3—0
	5*	10/18	32,000	45	4—0	1	..	1	..	2	8—0 (C)
	6*	10/25	....	46	1—15	1	..	..	..	1	1—15
	7*	10/26	....	42	0—12	1	..	..	..	1	0—12(D)
Railway's Standard.	1	9/26	33,300	49	7—0	1	2	..	11	4	28—0
	2	9/27	33,300	55	3—10	1	1	..	..	2	6—20
	3	9/29	32,800	53	9—10	..	..	2	2	4	36—40
	4	9/30	33,000	47	6—35	..	..	2	2	4	26—0
	5	9/30	33,000	45	5—05	..	..	2	2	4	20—20
	6	10/2	33,300	53	8—25	1	2	2	2	7	58—55
	8	10/8	33,300	53	65—0	..	..	..	..	4	260—0
	1*	10/8	33,300	53	5—10	..	2	2	..	4	20—40
	2*	10/12	33,300	49	5—50	..	2	2	..	4	23—20
	3*	10/14	.....	56	4—30	..	2	2	..	4	18—0
		10/14	.....	50	5—50	..	2	2	..	4	23—20
	4*	10/16	.....	45	2—30	..	2	2	2	6	15—0
		10/16	.....	50	1—35	..	2	2	2	6	9—30
	5*	10/18	.....	54	1—0	1	..	1	..	2	2—0
	6*	10/25	.....	50	12—30	1	2	..	2	5	62—30
	7*	10/26	.....	55	1—50	1	2	1	2	6	11—0
Summers No. 10384 "D. & I. R. Air."	1*	10/8	31,300	47	0—15	1	..	..	..	1	0—15
	2*	10/12	31,300	50	0—35	1	..	..	..	1	0—35
	3*	10/14	31,300	48	1—10	1	..	..	2	3	3—30
	4*	10/16	31,300	41	0—30	1	..	1	..	2	1—0
	5*	10/18	.....	47	0—25	1	..	..	..	1	0—25
		10/22	.....	43	0—20	1	..	..	..	1	0—20
	6*	10/25	.....	43	3—30	1	..	..	..	1	3—30
	7*	10/26	.....	43	0—38	1	..	..	..	1	0—38
	8	10/27	.....	37	0—15	1	..	..	..	1	0—15

(A) Bound, and doors would not close on account of plates in end of car. (B) 1 min. 25 sec. of this time consumed in trying to start ore by operating doors with air. (C) Doors not closed. (D) Doors not latched.
For Clark car No. 210, as per above figures, average of 8.56 min. per man per car, 4 failures.
For "Old Standard," as per above figures, average of 37.5 min. per man per car.
For Summers car, as per above figures, 1.16 min. per man per car.

*Where test numbers coincide, the ores, etc., were alike. See letter above.

to shake the ore out of the car with this cylinder. During the time of this experiment three men were struggling to get the ore out of the Summers car. Even as it stands the Clark car was operated in 3 mins. on this test while the Summers car required 3 mins. 30 secs. Had the experiment not been made with the air cylinder on the Clark car, it would have been operated by hand in 1 min. 35 secs., as against 3 mins. 30 secs. for the Summers car operated by air. Competitive test No 6 shows that the Clark car was completely operated by 1 man, by hand in 1 min. 15 secs., as against 3 mins. 30 secs. for 1 man on the Summers car with air. None of the items A, B, C, or D either show or indicate that the Clark car failed to operate in any instance. The troubles with the doors, therefore, should be classed as failures. It should be understood also that the Summers cars had every advantage in manufacture and shop work as compared with the Clark sample car, and that the latter car was not the same as the Clark cars now in service.

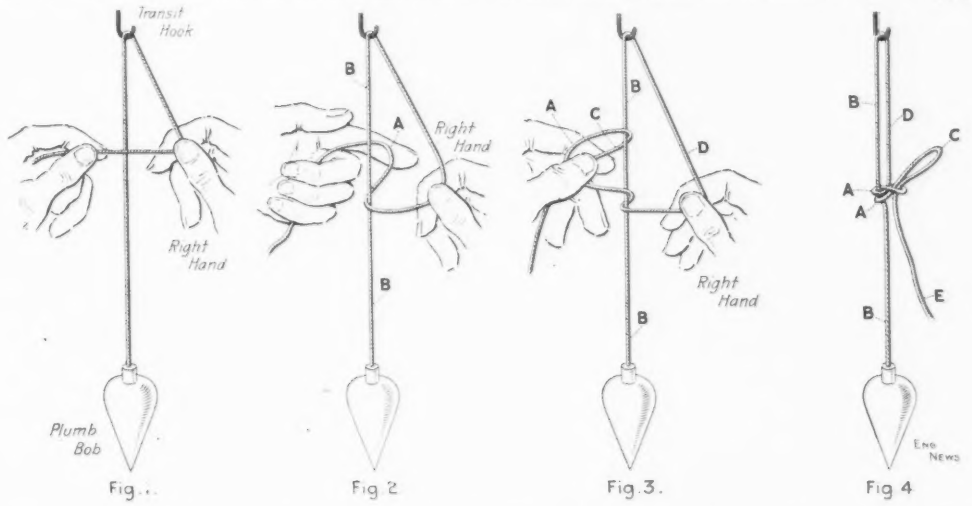
The fact remains that as a result of these experiments at Marquette and those carried on at Duluth, the Clark car has been sold to every road on which it has been demonstrated in competition with the Summers car; and it has received part of the order in every case except the L. S. & I. Ry., where it secured the entire order. We wish to thank you for the opportunity to answer Mr. Schaefer.

James S. Martin,
Engineer, Clark Car Co.

Pittsburg, Pa., Feb. 1, 1911.

A Plumb Bob Knot for the Transit.

Sir: The slip-knot here shown for tying the plumb bob to the transit is used by some of the surveyors in the anthracite region of Eastern Pennsylvania. It is particularly useful in that district because of the large amount of underground surveying where the plumb bob is hung above the transit. The common slip-knot, unless tied very tight, will occasionally slip when not desired, letting the bob fall upon the transit, which usually



results in breaking the glass of the compass-box. If the ordinary slip-knot is tied tight enough to insure safety there is difficulty in slipping the knot to adjust the length of string.

The following knot overcomes this difficulty, and requires no longer to tie than the common slip-knot. Figs. 1, 2 and 3 illustrate the steps in tying, and Fig. 4 shows the completed knot. Start as shown in Fig. 1; then make the loop A, Fig. 2, with the forefinger and bend forward and across B to the left until loop A takes the position shown in Fig. 3. Hold A with the thumb (Fig. 3), until C is pushed through it with the forefinger. Now let loose of D with the right hand and with it pull C on through loop A, which gives the final knot, as shown in Fig. 4. Pulling E, Fig. 4, unties the knot.

M. L. Lee.

423 West 118th St., New York City, Dec. 20, 1910.

[Various other ways of fastening plumb bob lines will be found in Eng. News, July 5, 1900, p. 9; Aug. 16, 1900, p. 109, and Sept. 29, 1904, p. 289.—Ed.]

State Sanitary Zeal and Ignorance in Oklahoma, with Particular Reference to Water-Supply and Sewage Purification at Oklahoma City.

Sir: While every effort should be made to secure a reasonable degree of purification of the sewage of the cities of this country, experience clearly shows that the complete removal of sewage pollution is not essential when water purification plants are established. Many cities are taking their water from streams even grossly polluted by sewage, and by applying modern scientific methods of purification and sterilization, have some of the lowest typhoid fever death rates in the country.

The same is true of many cities in England and on the Continent. Purification plants such as those established at Albany, N. Y.; Philadelphia, Pa.; Pittsburg, Pa.; St. Louis, Mo.; Cincinnati, Ohio; Columbus, Ohio; McKeesport, Pa., and many others, can no longer be considered as merely in their experimental stages. Proved statistics and scientific analyses are daily showing what these installations are accomplishing in the way of reduced death rates in these cities.

In Germany greater attention is paid to perfection in water-supply than to perfection in sewage effluents, and in that country we find the death rate from typhoid fever is 5.3 per 100,000 as opposed to 45 per 100,000 in America. Here the distribution of pure water is not considered so essential, judging by experience.

Yet, in spite of all this demonstrated efficiency, engineers are frequently set aside and derided by those in official positions who should know better. When we consider all that has been accomplished by purification installations in the way of reduced typhoid fever death rates in the many cities in this country, the concrete case of ignorance recently encountered by the writer on the part of state officials of Oklahoma seems almost past believing. Let the written and signed statements of Oklahoma's official scientific authorities upon this matter of water purification speak for themselves.

Some six months ago the writer was called in by the cities of Muskogee and Oklahoma City to design for them adequate and improved water-supplies, and in the case of Muskogee improved sewerage facilities and garbage disposal. In Oklahoma City the contract included the investigation of every possible source of water-supply for that city, and the recommendation of that source and plan which in my engineering judgment seemed wisest, best and most economical for the city to adopt.

Oklahoma City has for many years been obtaining its water from the North Canadian River, the average flow of which throughout the year is somewhere in the vicinity of 300 cu. ft. per sec. After a careful consideration of every other possible and impossible source of supply suggested by citizens and other engineers, the plan recommended by the writer included the construction of a dam upon this river, impounding about 8,000,000,000 gals. of water, sufficient to carry Oklahoma City through more than a year's drought, and a complete water-softening, purification and sterilization plant.

About 100 miles upstream, measured along the meanderings of the North Canadian River, is situated the town of El Reno, with a population of about 8,000 people; approximately 50 or 60 miles further up is another small town of about 2,000. Neither of these towns has a complete sewerage system. The average discharge of sewage at El Reno is ½-cu. ft. per sec., as compared with an average stream flow of 300 cu. ft. per sec. The town of Yukon, with a population of 1,000, situated at a river distance of 16 miles is at the present time installing a sewerage system, including a sewage-disposal plant.

Although the plans for the new water system for Oklahoma City provided for a complete and thoroughly up-to-date filtration and softening plant, including sterilization, the writer took the precaution to point out the advisability of the city's taking immediate action to see to it that the towns above were compelled to adopt some rational method of sewage purification before discharging the sewage effluent into the North Canadian River.

The question of voting $1,250,000 bonds to carry out the proposed plan for an improved water-supply was before the people of Oklahoma City for seven weeks, and received the endorsement of the City Council, the Chamber of Commerce, a citizens' committee which had been appointed to investigate the entire proposition, the Oklahoma State Engineering Society, and most of the most reliable men of the community, after each had given the proposed scheme of water-supply and purification their careful examination. The need of the city was very great, for during two or three months of the year 1902 and 1903, the river went practically dry, but the population of Oklahoma City at that time was only about 10,000 people, most of whom were supplied from wells. The present population of Oklahoma City is about 65,000 people, and during the past summer the flow of the river was not sufficient to supply the ordinary demands made upon it and for many hours the pumps had to be shut down and the city left without any fire protection whatever. Nor has the city a present supply sufficient to offer water to new industries, or to extend its mains.

Four days before the election certain state officials attempted to coerce the Mayor of Oklahoma City into going before the Legislature, then in session, to secure for them the passage of certain bills proposed by the State Commissioner of Health, which the Mayor had not seen, and which seriously affected every city and town in the state, under the penalty of their opposing the bond issue if their wishes were not acceded to. The Mayor opposed this principle of swapping votes, so to speak.

His statement in the papers regarding this matter was as follows:

I would rather go down to defeat, than to sacrifice the city of Oklahoma by agreeing to back a bill fathered by Dr. J. C. Mahr, State Health Officer, and Kate Barnard, State Commissioner of Charities and Corrections, which would require all cities in the state to construct a sewage farm which would mean to Oklahoma City more than $2,000,000 and to the state more than $25,000,000 as a whole. (From the "Daily Oklahoman" of Feb. 14, 1911.)

This statement was made by the Mayor after the following statements had been made, circulated and published over the signatures of the State Commissioner of Charities and Corrections, the State Health Commissioner, the State Chemist and the State Geologist. The campaign of opposition was opened by these state officials in the following published letter:

KATE BARNARD SEES DEATH IN RESERVOIR.

Editor The Daily Pointer: It is proposed that Tuesday we shall vote $1,250,000 bonds for a water-supply, and up to a few days ago the most of us supposed we were going to get water. Since then some frightful facts have been disclosed to us—facts in regard to this water, which means devastation and death unless somebody puts a stop to it, and because nobody else seemed willing to undertake to warn the people, I have accepted this grave responsibility and unpleasant duty.

Now, Mr. Voter, I wish to ask you some questions. Do you wish to drink liquid sewage? Do you wish to have the offal and filth from the sewers of El Reno and Yukon dumped into the water you drink? Are you willing to feed this liquid poison to your wife and child? Are you willing to vote $1,250,000 of your hard-earned money for a big pond of liquid filth? Do you wish the death rate of Oklahoma City to increase until it drives the tenants from your buildings and frightens investors away? Do you wish to feed them impure liquid poison so you may dig graves for your dead and make a huge cemetery and a small town of Oklahoma City? Do you wish to spread typhoid and epidemics and pestilence through the city we have all labored to build?

If you do not wish these things, then vote against the water bonds until a law is passed through our legislature compelling El Reno and Yukon to take their sewers out of our proposed water-supply. By all means vote against the bonds Tuesday and protect your loved ones from this infamous scheme to dam up a big pond of deadly disease germs.

Oklahoma City wants water; she needs water; she must have water—but she wants WATER, mind you, not a filthy liquid from the sewers of El Reno and Yukon. You have heard much from the engineers who are interested in making a per cent. out of the bonds. Come now and hear from those who are interested in promoting the health and lives and happiness of the citizens of Oklahoma City. These New York engineers may give us liquid sewage at $1,250,000, and then they may retire to their beautiful home on the banks of the Hudson River and drink from their own pure water-supply, but we will be left behind to bear the burdens and care for the dying and bury the dead and some of us are quite as much interested in protecting the health and lives of the citizens of Oklahoma City as are certain engineers in making a per cent. on a million and a quarter of our money.

I am perfectly willing, personally, and I am a taxpayer, to pay $20 a year for 40 years for clean wholesome water, but not one cent have I for sewage and filth and while I live it shall be over my protest that any engineer, for any amount of money, be permitted to feed liquid sewage to the helpless poor.

All those who are interested in the lives and health of the citizens of Oklahoma will please come to a public meeting at the court-house Monday night at 8 o'clock.

Kate Barnard.

Later, the State Commissioner of Charities and Corrections again said over her own name, and published broadcast, the following:

I thought of the typhoid epidemics in El Reno, the small-pox cases and social diseases which infect every city. I thought of the sewage from these sick bodies being treated by chemicals and then given to the mouths of our helpless poor to drink. I thought of the typhoid epidemics we have had in our city and I wrote our State Health Commissioner, Dr. Mahr, and our State Chemist, Dr. De Barr, and asked if in their opinion this sewage would be made safe for drinking purposes by subjecting it to the chemical process?

I have under seal Dr. Mahr's statement, and also a signed letter from Prof. De Barr in which both say this water "cannot be made safe for drinking purposes until the sewers are removed from the Canadian River," which is our water supply.

Again: I told them if they would wait ten days and pass a law through the legislature compelling the use of SEWER FARMS, such as they have in Europe and many states of America, thus removing the sewers from our water-supply, I would then stand for the bonds.

Again, on Feb. 12, Miss Barnard writes in the "Daily Oklahoman:"

Let us extend our main sewer five miles down the river, keeping it well above the water line as it now is, and then let us buy 600 acres of land and build an incinerating plant. Here we would burn the dry sewerage and pass the liquid through chemicals reducing the odor and with this fertilizer, then as Pasadena, Cal., is doing, we could raise bumper crops of corn and walnuts. All of these sewer farms report them as "a profitable undertaking." This is the system America and Oklahoma must come to if we all perish and if Oklahoma City continues her present record for typhoid and other epidemics it will be a land shunned by home seekers and investors. Who wants to enter an area of great mortality? Would you go this instant and take residence in a town cursed with disease and polluted water?

The letter of the State Health Commissioner, which the Charities Commissioner stated she had was published in the "Daily Times" of Oklahoma City, and again in circulars distributed at the polls, and was as follows:

Dear Miss Barnard: Replying to your request for my opinion as a health officer as to whether or not a stream like the North Canadian River, that is now sewerage [sic] polluted and continually receiving every day additional sewerage [sic] pollution, can be dammed up and the water from the same be made a good and wholesome water for domestic purposes and used without endangering the health of those who use it for drinking purposes, I beg to advise that personally my opinion would be that it could not be sufficiently purified, unless the sewers [sic] were removed and the river policed, so as to prevent a continuation of the contamination. In Ohio, Indiana and Kansas an aggressive fight is being waged against the further contamination of the running streams of water now used by municipalities for domestic purposes.

Yours truly,
(Signed) J. C. Mahr,
State Commissioner of Health.

Concerning the El Reno and Yukon sewage entering the river, the State Chemist, Dr. De Barr, made the following statement:

After entering the stream no treatment that will make the water safe as a drinking water for Oklahoma City can be applied to remove the evil effects of this sewerage [sic]. The only way is to not allow this sewerage [sic] to enter the reservoir if you expect a pure water for Oklahoma City.

In view of the above statements, made by the scientists of the state of Oklahoma, it is interesting to remember that the water entering the Columbus, Ohio, storage reservoir is polluted by a tributary population of 70 persons to the square mile, while the tributary population at the proposed reservoir at Oklahoma City is at the present time not more than five persons per square mile. The watershed of the Sciota River from which Columbus draws its water-supply is 1,035 sq. mi., and that of the North Canadian River is 15,000 sq. mi. In other words, the proportion of pollution in the Columbus reservoir to that of the proposed Oklahoma City reservoir is as 16 to 1.

The State Geologist, Chas. N. Gould, added his word to this controversy over his own signature, as follows.

Speaking of the proposed reservoir and purification and softening plant he says:

The quality of the water will not be materially improved. The people of Oklahoma City will continue to drink the sewerage [sic] of El Reno and other towns. The dead horses and cattle from the hundreds of farms and Indian allotments in western Oklahoma will still be dumped into the river and many of them will wash down into the reservoir. The water will always be hard and will require the constant use of chemicals.

According to Government statistics on file in the office of the State Board of Health, Oklahoma leads other large cities in the percentage of typhoid cases. Bacteriologists tell us that no stream or reservoir will purify itself and that no filter so far designed will take out all the typhoid germs. The fact that the people of other cities, such as Pittsburg and Wheeling, drink sewerage [sic] and die of typhoid is of itself no reason why the people of Oklahoma City should do the same thing.

Personally, this whole matter would be most amusing if it were not for the fact that these opinions, coming from those who should be leaders of thought among the people, were taken as gospel truth and caused the people to stampede.

Alexander Potter,
Consulting Engineer.

114 Liberty St., New York, Feb. 22, 1911.

[Zeal and ignorance make a team that are likely to go fast and far, but far astray. That this has proven true in this Oklahoma controversy we need not tell any competent sanitary engineer, chemist or bacteriologist who reads the utterances cited in the foregoing letter as coming from four state officials of Oklahoma. Perhaps the sanitary ignorance of the commissioner of charities is excusable and that of the geologist partly so—or at least both might be excused did they not make themselves blind leaders of the blind. But a state commissioner of health and a state chemist ought to know the fundamental principles of water sanitation sufficiently well so they would not seem to place more confidence in sewage purification than in water purification.

How many years will it be before laymen, whether commissioners of health or of charities, learn that burning sewage is impossible; that sewage farms are no longer adopted in new installations in Europe, are particularly unsuited to American conditions and have rarely if ever paid running expenses and capital charges anywhere; that sewage purification alone cannot be relied upon to protect streams used for drinking water; and that a combination of water storage in an immense reservoir, with subsequent filtration, followed if need be by disinfection with hypochlorite of lime or soda is the best safeguard that can be afforded to any water-supply subject to sewage pollution?—Ed.]

The Basis of Apportioning the Cost of the Massachusetts Metropolitan Water System Between the Various Communities Affected: A Correction.

Sir: I desire to call your attention to several inaccurate statements regarding the method of apportioning the cost of the Metropolitan Water Works, which appeared in the Engineering News of Feb. 23, 1911, in an article by Mr. J. A. Holmes.

The Metropolitan Water Act, as enacted in 1895, did not provide for the appointment of a commission to divide the cost, but provided that beginning with the year 1898 an assessment of $300,000 should be levied, to be increased $200,000 annually until the amount levied should be equal to the amount necessary for the payment of the annual interest, sinking-fund charges and cost of maintenance.

The city of Boston was required to pay the proportion of the total assessment which its assessed valuation bore to the total valuation of the entire Water District, allowing, however, but one-sixth of the valuation of towns which were included in the district but were not supplied with water. The portion of the assessment paid by the cities and towns outside of Boston was divided one-third in proportion to their respective valuation and two-thirds in proportion to their population, the cities and towns not taking their supply from the Metropolitan Works being required to pay but one-sixth of the amount which they would have paid had they received their supply from the Metropolitan Works.

In 1900 it appeared that the amounts arbitrarily fixed by the Act were much less than were needed to meet the interest, sinking fund and maintenance requirements, making it necessary to pay these charges from loans, and the law was modified so that in 1901 and subsequent years the full amount has been assessed upon the District.

In 1906 the quantity of water used was substituted for population in apportioning the assessment of all municipalities supplied with water, with the exception of Boston, which still paid in proportion to valuation. The proportion paid by cities and towns which did not receive a supply from the Metropolitan Works was at the same time changed to one-fifth of the amount payable on account of valuation, with no charge whatever on account of consumption. In 1907 and subsequent years the cities and towns, including Boston, paid one-third of the amount required to pay interest, sinking fund and maintenance expenses in proportion to their respective valuation in the preceding year, and the remaining two-thirds in proportion to the consumption of water in the preceding year by the cities and towns respectively. In the cities and towns not using water but one-fifth of the valuation is used in determining the assessment and no charge whatever is made on account of water used.

Dexter Brackett,
Chief Engineer of Water Works,
Metropolitan Water and Sewerage Board.

1 Ashburton Place, Boston, Mass., Feb. 25, 1911.

More Discussion of License Laws for Engineers.

Sir: As an old subscriber to Engineering News, I am surprised and shocked to read your editorial in your issue of yesterday upon "The various bills" to license engineers in New York because it does not ring true under the hammer test.

Perhaps (to use your own words) "there are several reasons for this. One is that the editors are too fully occupied with their regular work to take the time to study and prepare opinions upon matters of ordinary engineering practice which should properly be given special study by some engineer competent in the particular field to which they relate."

You speak of lawyers and doctors in your discussion of the engineer as a licensed practitioner, and I am pleased that you have chosen two examples so nobly filled and so widely known in genuine appreciation by us all. Yet you, of all others, should know that all lawyers are not able to lead the Bar Association, nor perhaps be a top-notch corporation attorney, nor perhaps be the brightest star anywhere visible in that vast universe of usefulness as each shines true his light (perhaps reflected) to make the heavens appear the more blue and our pathway the brighter as we endeavor to miss the thorns and briars and stumps of life's journey.

You, of all others, should know that all doctors are not specialists in every line of that splendid profession, yet you do not deny that some are skilled in surgery and still others in the grand speciality of obstetrics, etc., etc., even though licensed under the laws of this state of New York. Why take a fling at the engineer? Why not be as charitable toward him? Are we to read your words as expressing "Battery opinions" and merely giving "advice to brother members of the profession without charge"?

I had the great pleasure of listening to Professor Chandler, of Columbia University, the other evening in his earnest presentation of facts in unstinted support of the McGrath Bill No. 96, as opposed to the Hoff Bill No. 309, and, as illustration, he told in his charming way how "licensed" doctors welcomed our arrival into the world, and how even "licensed" undertakers saw that we were "shoveled off" properly, yet how our bridges we cross, our water we drink, our towering buildings we occupy, our roads we travel in life, and the myriad examples of the "profession" of engineering saw nowhere about them during construction a licensed engineer as a uniform guarantee expressed to the living public such as a license would tend to give.

The sentiments so splendidly expressed by Mr. W. Newbrough on p. 235 of the current issue of your valued paper I wish most heartily to endorse.

In closing I would most earnestly "urge our readers resident in New York state (including the writer of this 'editorial') to inform themselves" about the Assembly Bill No. 96 introduced by Hon. Patrick J. McGrath, then I feel sure that they too will see that, if the "licensed" lawyer and doctor do have good arguments in their favor, perhaps we, as humble engineers, can be likewise honored and protected in the eyes of the public by openly advocating the passage of this splendid Bill No. 96, and not the Hoff Bill No. 309.

Very truly yours,
J. Calvin Locke.

1880 West Seventh St., Brooklyn, City of New York, Feb. 24, 1911.

[We presented some of the reasons why licenses for engineers promise no benefit, either to the public or to the engineering profession, in our issue of Jan. 26. If our correspondent has carefully read that article he must have discovered that our opposition to any license bills affecting the engineering profession is based on our belief that any such legislation will work serious injury to the profession and no benefit to the public.

The McGrath bill referred to, does not include mechanical, mining and electrical engineering practice, but it places the engineering profession and the engineering schools under the authority of the Board of Regents of New York, a body which has already done enough to injure education by its machine regulation of curriculums and examinations and ought by no means to be given any additional authority.

As for Prof. Chandler's quoted argument, does anybody who knows engineering from the inside really think that "the bridges we cross, the water we drink, the towering buildings we occupy," would have any greater safety or economy of construction, if all that examination machinery which the McGrath bill proposes were set in motion and the engineers who worked on these things all had licenses? For nearly a quarter of a century this journal has given special attention to the investigation of disasters in which engineering work was involved; and in cases where an engineer has been at fault, the error has been due to lack of experience and good judgment rather than lack of scholastic training.

Further than this, the public safety can be and is protected at the present day far more adequately and certainly by inspection of the engineer's finished work than it could be by any cut-and-dried examination and license system. The bridge engineer's work is subject to inspection by the Public Service Commission, the high buildings have to pass the inspection of the city building department, plans for sewage disposal and water-supply must pass the inspection of the State Board of Health. By that method the public can be protected; but the attempt to test engineering ability and give it all one uniform brand can afford no protection to the public against incompetent work.—Ed.]

Sir: I am deeply interested in the question of licensing engineers which is now being agitated in New York State owing to pending legislation on the subject there. I am most forcibly impressed by your editorial arguments in opposition to the proposed measure, and particularly so by these words which I quote from the issue of Feb. 23:

There is about as much sense in such a proposition as there would be in declaring under the State's official seal that a man was properly qualified to keep a hotel, run a steam shovel, act as cashier of a bank, fill teeth in a dentist's office and practice law.

To my mind, these words sum up the proposition and

present it in a light so ridiculous that it should be unnecessary to offer any other objection. The profession of engineering which has been evolved in a few generations from "Civil Engineering" in contradistinction to "Military Engineering," has developed into such an immense and diversified field as to make it absolutely out of the question for any man or combination of men to judge who is qualified to practice the profession, by submission to any form of examination that could possibly be devised.

The issuance of a license under the proposed law would be equivalent to declaring that the holder thereof had proven himself capable of making land, marine, topographical, geodetic and mining surveys, calculating them, plotting them on maps, and laying out various and intricate works upon the maps and in the field; designing and supervising the construction of everything from a plank culvert across a country road to a Firth of Forth bridge; boring Simplon tunnels and North River tubes; building Niagara power plants and Pennsylvania terminals; digging Panama Canals, and surmounting Rocky Mountains with Union Pacific Railways; sinking Red Jacket shafts a mile into the earth, and equipping them to hoist ore to the surface in a minute; constructing Eddystone Lighthouses and Mississippi Jetties; designing and building "Dreadnoughts" and "Lusitanias"; erecting Singer and Metropolitan Life buildings; building Assuan Dams and Cape to Cairo Railways. He would be armed with a certificate of proficiency to design great steam, water and gas engines, and the million of machines they are intended to drive.

Will the commission having the examination in charge be composed of specialists in railroad, hydraulic, bridge, municipal, sanitary, mechanical, electrical, architectural, mining, metallurgical, chemical, marine, agricultural, forestry and textile engineering? Will all of these eminent scientists have a whack at the poor young chap from a mountain country with aspirations to the job of county surveyor?

Another important point in your argument is that no honorable engineer will undertake work he is unqualified for by training and experience. I might go still farther and say that mighty few of us can get work unless we are so trained; and that we necessarily have to confine ourselves to work we are capable of performing. If we do get beyond our depth and can't make good, we are pretty sure to be "fired" before any lives are lost through our incompetence.

The professions of law and medicine are very different from that of engineering in that they have practice embracing all sorts and conditions of people, and it is only right that the ignorant and simple minded should be protected by law from "jack-legs" and "quacks." Engineers usually deal with people of education, breadth of view, and sufficient means to afford their services. The ignorant, narrow and penurious do their own engineering work by rule of thumb, and no law can force them to do otherwise

I recently had a few weeks' work making laboratory tests and drawings and calculations in New York for London parties. Would I have had to take out a license under the proposed law? Mining Engineers are a particularly nomadic branch of the profession, and if each state should adopt a license law all its own, they would have a glorious time taking examinations and paying license fees every time they made examination trips. I wonder if their employers would consider the time and money spent as legitimate expenses.

Benjamin H. Case.

Asheville, N. C., Feb. 25, 1911.

Sir: At a meeting of the Council of the American Institute of Consulting Engineers on Feb. 24, it was decided to oppose all the bills now pending in the Legislature at Albany to license civil engineers, and the President, Mr. Alfred P. Boller, and the Committee on Legislation of the Institute were instructed to attend the hearings on these bills at Albany, and to use all legitimate means to prevent their passage; also to cooperate with other engineering bodies having a like object in view.

E. W. Stern,. Secretary.

New York, Feb. 27, 1911.

Notes and Queries.

In the article by Mr. Alexis Saurbrey entitled "Further Notes on the Collapse of the Henke Reinforced Concrete Building" in our issue of Feb. 23, 1911, p. 238, the rods in the basement and first floor columns (Fig. 2) should have been ten 1¼-in. for the basement and four 1¼-in. and six 1⅛-in. for the first story. The discrepancy referred to in the note on the drawing is between the 12 rods shown in the basement column and the description appended thereto calling for "10" rods.

CORRECTIONS.—Two errors occurred in the titles to cuts in the article on Excavating machinery in our issue of Feb. 23. By a typographical mistake the machine in Fig. 5 (p. 217) was called a "Buckeye" instead of a "bucket" machine. The address of the maker of the dipper dredge in Fig. 7 (p. 218) was incorrectly given, as the Vulcan Co. is at Toledo instead of Marion, O.

A typographical error in the article on "Over-Driven Piles, Brooklyn Fourth Avenue Subway Construction," p. 224 of our last issue (Feb. 23, 1911), created a false impression of the method of excavation used in the Tide-Water & Bryson section of the subway. The steam-shovel took out about 80% of the total excavation, instead of 30% as it appeared in the article. The facts regarding the work will be shown in detail in an article which we hope to print shortly.

Tile Drainage for Reclaiming Wet Lands.*

By C. G. ELLIOTT,† M. Am. Soc. C. E.

When my attention was first called to the effects which followed underdraining it seemed that the mere removal of surplus water from the soil was not a sufficient cause for the salutary effect which draining had upon the crop production. New life, vigor, and nutriment seemed to be imparted to the plants and continued with them until they matured. We were contented to ascribe such benefits to better aeration, more uniform temperature, and improved mechanical condition of the soil.

We have learned in recent years something of the office of nitro-bacteria in converting free nitrogen of the air into soluble nitrates which are required to nourish growing plants. The presence of oxygen and the increasing warmth and uniform conditions of moisture brought about by good drainage are conducive to their multiplication and activity. They are found to exist in temperatures of 41°, but are most active in soils with temperatures of 70 to 90°. They do not flourish in saturated soils.

The porosity of tile as a factor in drainage has been advocated from time to time. Some experiments were made recently by our office at Washington to ascertain the value of this property in practical drainage. Medium soft tiles made of brick clay were selected and when immersed they absorbed about 20% of their own weight of water. When subjected to tests for several days the following conclusions were deduced regarding the facility with which water under the most favorable conditions would pass through the walls of the tile. If a field were drained with lines of 6-in. tile of this quality, laid 50 ft. apart and no water permitted to enter through the joints, it would require 139 days for them to remove ¼-in. of water from the land. With 3-in. tile, it would require 250 days to accomplish the same result. In other words, if the joints of a drain composed of these tile were closed, it would require 139 and 250 days, respectively, for them to accomplish the drainage which is ordinarily required in one day.

An interesting demonstration upon this point was made last year by the State Agricultural College at the New York State Fair. Drain tiles, closed at one end, were filled with water and allowed to remain during the week. Though no water was added, the tiles remained nearly full. These conclusions regarding porosity might be further corroborated by examples from the field, where occasionally tiles are so closely joined that water does not enter the drain in sufficient quantities to serve the required purpose. While many difficulties which are encountered in draining would be overcome if tiles with closed joints could be used, the fact remains that their usefulness depends upon the ground water entering the drain at the joints.

One phase of development which is particularly noticeable, since the introduction of under-drainage, is the increasing size of tiles for lateral drains. At one time 1-in. pipes were regarded as sufficient for laterals in England. Large numbers of 1½-in. tiles were used in draining Central Park, New York, and 2-in. tiles were generally employed when under-drainage was first introduced in this country. At present, no smaller than 3-in. tiles are used, and 4-in. and even 5-in. for laterals are considered superior to smaller ones even in hardpan and gumbo soils, where frequent drainage is required. Tae fact that drain tiles have a double office to perform, that of a conduit for air as well as water, is fairly well recognized by careful observers in soil physics. The use of the larger lateral drains in many cases produces a more salutary effect upon close soils or those which are difficult to drain. At all events 4-in. lateral drains are in more general use in the middle west than those of smaller size.

Another development is the demand for pipes ranging from 18 to 36 ins. diameter, which are now frequently substituted for open ditches in main drainage works. This has imposed new requirements upon tile manufacturers and upon engineers, due to the fact that greater strength of pipe is required and that a nicer adjustment of hydraulic factors is required in order to secure necessary economy and efficiency. No other country uses large drains of this character for purely agricultural purposes. The further extension of this class of work will depend largely upon the ability of manufacturers to meet the severe tests to which drains of this kind are subjected.

Drainage as an agricultural improvement is more widespread and general than has heretofore been known in this country. The gradual reclamation of lands in the south and east is creating a demand for drain tile in localities where it has never been used. There are 25,000,000 acres of land in sight which will, within the next 15 years, demand drain tile in the natural course of their development for agriculture. More intensive cultivation of the sections which are reputed to be thoroughly drained will create a constant though not large demand for tile, while the desire to more completely utilize valuable land will require that open ditches be converted into covered drains.

There are not less than 800,000 acres of irrigated land in the west which require draining. Some of this area is abandoned and useless because of over saturation and because of the evils which follow in the train of seepage. The opening up of newly irrigated lands is yearly increasing the areas which require draining. While wooden box drains are used in many localities, drain tiles are more desirable and should be employed whenever they can be obtained. Small tile have but a limited use in draining irrigated lands, the sizes best adapted to the work ranging from 6 to 12 ins.

It may be interesting to note that the extension of drain tile in agricultural operations is not confined to the lands of this country. The farmers in the Haarlem Meer, the great drained lake of Holland, are introducing this improvement on their clay lands. Field drainage is ordinarily accomplished by parallel ditches which take the form of deep furrows. These are being replaced in some instances by drain tile, and level surface culture substituted for the ridge method.

The most unique field for the use of drain tile may be found in the moor lands of Germany. There are more than 5,000,000 acres of these lands, most of them in government ownership, which yield no revenue and support but few people. Notwithstanding the efforts so far made to reclaim and utilize this vast area of waste land, only about 15,000 acres have been converted into productive fields.

The land is virtually a bog with water lying at the surface and held by the vegetable, spongy material of which the moor is composed. In the most approved process of reclamation, drain tiles 2 ins. in diameter are laid in lines about 65 ft. apart and 3½ ft. deep. The very salutary effect of this drainage combined with subsequent special treatments of the lands has proved that they can be reclaimed and cultivated at a profit.

*Abstract of a paper read at the 33rd annual convention of the Illinois Clay Manufacturers' Association, at Chicago, Jan. 17, 19.

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The Report of a Board of Engineers on the Illinois Section of the Lakes-to-the-Gulf Waterway.

In our issue of June 24, 1909, we published the report of the Board of Engineers appointed to report on the proposed improvement for navigation of the Mississippi River from St. Louis to its mouth. The report of that Board was to the effect that an available navigable depth at low water of 8 ft. from St. Louis to Cairo and 9 ft. from Cairo south was as great a depth as would be justified by the present and prospective traffic upon the river.

By the River and Harbor Act of 1910 a special Board of Engineers was ordered to report upon a project for an improved waterway from Lockport, Ill., to the mouth of the Illinois River. As our readers will recall, the State of Illinois has had before it for some years the project for spending $20,000,000 upon this waterway with the idea that the water power to be created will repay to the State a large part of the cost. An amendment to the State Constitution permitting the creation of a bonded debt for this purpose was adopted by popular vote in November, 1908.

Since that time, however, the popular sentiment in favor of the project is said to have changed and in two successive legislatures the bill to carry out this $20,000,000 project has failed of passage. The bill is again before the present legislature, however.

The special Board of Engineers was appointed to advise what part the Federal Government should take in cooperation with the State of Illinois in this project. Its report, presented on Jan. 23, is particularly notable for its clear and logical discussion of the problem: What is the economic depth of an inland waterway? The Board agrees with previous boards that a depth of 8 to 9 ft. is sufficient for all commercial needs now apparent. We print a large portion of this Board's report below:

Report by a Special Board of Engineers on Waterway From Lockport, Illinois, to Mouth of Illinois River.

In the numerous surveys for a waterway from the Great Lakes to the Mississippi River, the line from Bridgeport, on the South Branch of the Chicago River, to Lockport, on the Des Plaines, thence along the Des Plaines River to the Illinois, and along the Illinois to

its mouth, has uniformly been considered the most feasible. Since the Chicago Drainage Canal has been excavated through the Chicago divide and now insures an adequate supply of water for the channel, the canalization of the Des Plaines and Illinois Rivers, with short canals around rapids, has been generally recommended. In the valley of the Des Plaines and upper Illinois rivers the rock is sufficiently near the surface to provide excellent foundations; the lower Illinois has an exceptionally gentle slope, averaging about 0.13-foot per mile, so that any reasonable depth can be obtained by dredging.

The Most Favorable Depth and Dimensions for the Waterway.

Waterways from the Great Lakes to the Mississippi River have been proposed varying in depth from 4½ to 24 ft. In determining the most advisable depth of the waterway it is necessary to consider the probable commerce, its character, its origin, its destination, and the dimensions of the vessels in which it can be most economically transported.

Experience has shown that as a general rule coarse and bulky articles seek water transportation, while the finer manufactured products are shipped by rail. Of the 62,363,218 tons transported through the St. Mary's Falls Canals in 1910, about 97% consisted of iron ore, coal, grain and lumber. Crude manufactured products, such as pig iron, ingots, and steel rails, are also naturally shipped by water, and in thickly settled communities like New York there is a large water commerce in building materials, such as brick, stone, lime, cement, sand, and gravel.

The Illinois River flows through one of the richest farming regions of the United States. There are along its banks large mineral deposits, especially coal, building stone, and the ingredients for making cement, so that the valley itself is capable of producing a large amount of the commodities which seek water transportation. The natural markets for this section are now Chicago and St. Louis, and were both New Orleans and the Northwest connected with the Illinois River by suitable water transportation they might become additional markets. There are four sources of possible commerce for the proposed waterway: First, its immediate banks; second, the tributary rivers; third, the Great Lakes; and, fourth, the Gulf of Mexico.

The types of vessels which can most economically handle such commerce differ radically. A vessel navigating the ocean has to combat violent storms and severe wave action, and requires such relations between length, width, and depth as to secure good lines, great stiffness of hull, and maximum stability. For ocean service the experience of the past 50 years has evolved an economic freight steamer with a draft between 20 and 30 ft., though at a few of the principal ports vessels drawing from 30 to 40 ft. are being introduced.

On the Great Lakes, since storm waves are not as large as on the ocean, and harbors of refuge are more frequent, less structural strength is necessary in vessels, and for the same draft the displacement may be much greater than on the ocean.

Experience on the Great Lakes has evolved an economic bulk cargo steamer with a length of 550 to 600 ft., which, when loaded to an ultimate draft of 21 to 24 ft., carries a cargo of 10,000 to 15,000 tons. The package freighter employed on the Lakes by the various railway corporations is of somewhat smaller dimensions and has a draft of 18 to 19 ft. These two types of vessels now carry the bulk of the iron ore, coal, grain, and merchandise of the Great Lakes and the cost of transportation has been reduced at least half in the past 20 years.

On rivers, vessels are not exposed to wave action, and their structural strength and draft for the same displacement can therefore further be diminished. The early river packet was a frail stern or side wheel steamer having a draft of 3 to 10 ft., but as a freight carrier it has now been generally displaced by barges, which experience has demonstrated to be more economical. These barges have a draft not exceeding 8½ ft. and a capacity up to 3,000 tons. They are assembled in tows and handled by a powerful towboat, in which the same economies in steam consumption are obtained as in the modern lake or ocean steamship.

The experience of foreign nations in river navigation is similar to that of the United States, as is illustrated by the enormous traffic of the River Rhine which, according to the "Statistik des Deutschen Reichs, Band 226," amounted in 1908 to about 54,000,000 tons between Strassburg and the Dutch frontier. The low-water depth of the channel upon which this large volume of freight was carried, as described in the preliminary report of the United States National Waterways Commission, 1910, was only 9.8 ft. for 10 miles from the Dutch frontier up to Cologne, thence 8.2 ft. for 82 miles to St. Goar, thence 6.6 ft. for 79 miles to Mannheim, and thence 4 ft. for 84 miles to Strassburg.

About 30% of the traffic of 1908 used the river above Cologne where the available depths vary, as above stated, from 4 ft. in the section immediately below Strassburg, to a maximum of 8.2 ft. in the section immediately above Cologne. Bulky commodities are transported in fleets of barges towed by special steamers designed for the purpose.

The United States consul general at Berlin reported to the Department of State under date of Aug. 18, 1909, that the capacity of the largest Rhine barges is over 2,600 tons, with a length of 336.6 ft., a beam of 39.6 ft., and a maximum draft of 9.4 ft.; that the largest Rhine towboat has a length of 249.3 ft., a breadth of 29.5 ft., and that the most powerful have from 1,300 to 1,450 HP.

Under date of March 7, 1910, he reported that the Rhine boats on an average are 237 ft. long and 30.6 ft. beam, with carrying capacity of from 480 to 1,000 tons on drafts of 4 to 7½ ft. Package freight is carried in separate steamers, and he stated that the capacity of the largest Rhine freight steamer is 975 tons, with a draft of 7.9 ft., a length of 278.9 ft. and a breadth of 29.5 ft.

According to a report made by Maj. F. A. Mahan, Corps of Engineers, retired, in 1903 the total number of sailing vessels and towed barges on the Rhine was then 8,379, and the total number of towboats was 745, while of other steamers of all classes there were but 378, including 156 package freight steamers.

According to information furnished by the American consul general at Frankfort in 1908, the Rhine fleet consisted of 1,318 steam vessels with indicated horsepower of 295,849 and 9,759 barges with a carrying capacity of 3,960,378 tons, or 11,077 vessels in all.

These figures plainly show the predominating character of towboat navigation. No other river of Europe carries a commerce comparable with that of the Rhine, and it is clear that for the proposed waterway a channel equal to that now found on the Rhine will be adequate for an immense traffic.

From the preceding it follows that if the waterway is to be used by vessels capable of navigating the ocean and the Great Lakes, it should be given a depth sufficient for the economic carriers above described, and this, in the opinion of the Board, should be not less than 24 ft.; but if it is to be constructed for vessels adapted to river traffic, economic navigation does not require its depth to exceed 9 ft.

The depth of 14 ft., so strenuously insisted upon by certain advocates of the waterway, is greater than necessary for river navigation, and entirely insufficient for either lake or ocean vessels. The only canals of 14 ft. depth of which the board has knowledge are the Canadian canals along the St. Lawrence River and the Welland Canal connecting Lakes Erie and Ontario, which were constructed in the infancy of lake navigation. Little use is now made of them for transportation to and from Chicago. This depth has not been adopted by any other nation, nor retained by Canada in recent projects.

A 24-ft. waterway from Chicago to the Gulf has never been considered by Congress, but its cost would be enormous, and even if constructed, it would never be used commercially by the vessels for which designed. Barge navigation on rivers has been developed to such efficiency that it is estimated in House Document No. 492, 60th Congress, 1st session, that coal can be shipped from Pittsburg to New Orleans in a 9-ft. channel for 0.376 mills per ton-mile, which is a low rate even for lake and ocean vessels of 21-ft. draft. Both lake and ocean vessels are designed for use in waters of great depth and unlimited width, which they navigate with unrestricted speed and comparative safety; but on rivers, canals, or other contracted waters, they must materially reduce their speed and sometimes require assistance by tugs.

In the report of the committee on the canals of New York State, 1899, it is shown that the first cost of lake vessels is so great, and their rate of speed on canals so slow, that interest charges alone will prevent them from competing with barge navigation. Moreover, on the Mississippi River, with its swift current, crooked channels, and other difficulties of navigation, insurance charges would place them at a further disadvantage as compared with the ordinary river craft.

Ocean, lake, and river boats have each been specially designed for the work they have to perform, and when diverted therefrom, lose in economy. Should a lake vessel drawing 14 ft. attempt to engage in commerce between Duluth and Liverpool via the Mississippi River, it would be in competition with the modern lake freighter from Duluth to Chicago, the modern barge and towboat from Chicago to New Orleans, and the modern ocean freighter from New Orleans to Liverpool, each specially adapted to its portion of the route and able to carry freight for less than one-half the rate the vessel of 14 ft. draft would be forced to charge.

Considered as a business investment, a waterway of even moderate depth from Chicago to the Gulf is still more or less experimental. There is already maintained under existing projects a channel of 9 ft. depth from New Orleans to Cairo, and of 8 ft. from Cairo to St. Louis, and of at least 4½ ft. from St. Louis to Chicago via the Illinois and Michigan Canal. With the exception of coal from the Ohio River, the existing commerce on any portion of this route is small.

To justify even existing expenditures, commerce must be developed in the tributaries, and until it is created a further enlargement of the main stream will not be warranted. A uniform depth in the Mississippi and its leading tributaries will be far more beneficial to the navigation interests of the United States than a main channel of great depth with shallow feeders. As a channel of 8 ft. depth is now maintained from Cairo to St. Louis, and can be extended from St. Louis to Utica at relatively small cost, business caution dictates that a waterway of this depth be obtained and tested before entering upon enormously expensive projects of questionable utility.

Should commerce respond to these comparatively moderate expenditures and utilize the waterway provided, and should an increasing traffic demonstrate the necessity for additional depth, then a channel of 9 ft. depth can be constructed from Cairo to Utica. This can be obtained at a small additional cost and will correspond to the depth provided by the existing projects for improving the Ohio and lower Mississippi Rivers. For the locks and other new constructions between Utica and Lockport the extra foot of depth should be obtained at the outset, since its cost will be comparatively small.

When a 9-ft. waterway has been provided between Chicago, St. Louis, New Orleans, and the cities in the Ohio Valley, should navigation keep pace with the improvement and still greater depths appear economically desirable, they may be created without sacrificing the work now recommended by the Board. In such case, the original locks will still be valuable to provide for the smaller craft which will continue to navigate the minor tributaries as well as the main stream.

The course thus outlined corresponds to that which the Government has so successfully pursued with the large commerce on the Great Lakes, where it has deepened and enlarged channels as navigation has required. Harbors of 23 ft. depth and the new 24½-ft. lock at the St. Marys Falls Canal are now logical; but to have constructed them when the navigation of the lakes was confined to vessels drawing but 12 ft., would not have been a judicious expenditure of public funds. The old Weitzel Lock is still profitably utilized for the passage of light-draft boats, and thus relieves the new deeper locks, which are frequently taxed to their full capacity.

The board considers a bottom width of 160 ft. in canal and 200 ft. in the open river above the mouth of the Illinois sufficient for a channel of 8 or 9 ft. available depth. For safety and ease of navigation the channel should be excavated to 11 ft. in rock cuts and canals, and the locks should be given 11 ft. depth, 80 ft. width, and 600 ft. useful length. With these lock dimensions three barges, carrying about 9,000 tons of freight, may be locked through with their tow boat.

A waterway of these dimensions would have a capacity exceeding 100,000,000 tons per annum, and would accommodate barge tows carrying about nine times the ordinary train load of this vicinity. In addition, the vessels using it would be capable of navigating the Ohio and lower Mississippi Rivers. Such a waterway will not require a diversion of more than 1,000 second-feet from Lake Michigan, and this amount would not injuriously lower lake levels nor cause excessive flooding of lands in the Illinois Valley.

Cooperation With the State of Illinois.

On Dec. 8, 1910, the Hon. Charles S. Deneen, governor of Illinois, accompanied by Mr. Isham Randolph, chairman, and Mr. Robert I. Randolph, secretary, of the Internal Improvement Commission of Illinois, appeared before the Board and made an explanation of the policy and plans of the State in connection with the development of the proposed waterway.

Briefly, the project presented by the State of Illinois contemplates the development of water at four sites between Lockport and Utica, and the improvement of navigation by the construction of five large locks, 80 by 900 ft. in horizontal dimensions, with 24 ft. depth on their miter sills. The uppermost lock of the series will be at Lockport connecting with Lake Michigan, and the lowest will be at Utica, connecting with the already improved portion of the Illinois River. The locks between Lockport and Utica are to be connected by channels 300 ft. wide, 24 ft. deep as far as Lock No. 2 at Brandon Bridge below Joliet, and thence to Utica of not less than 9 ft. immediate, and not less than 14 ft. later, depth, and a bottom width of not less than 200 ft. These channels are to be in the river bed, except at the mouth of the Des Plaines River and at Marseilles, where short sections of canal are proposed.

This project is practically the same as that printed in the 1909 report of the Internal Improvement Commission of Illinois, and the estimate of cost is $19,957,517. It differs from any heretofore submitted to Congress in that it proposes the utilization for power purposes of the water which may flow through the Chicago Drainage Canal and contemplates an ultimate channel depth of 24 ft. for navigation purposes, though the estimates provide for 24 ft. only to Brandon Bridge and for 14 ft. below.

The Board of Engineers whose report on a survey for a navigable waterway, 14 ft. deep from Lockport to the mouth of the Illinois River is published in House Document No. 263, 59th Congress, 1st session, estimates the cost of the same portion of the route at $15,647,902, but its plan contemplates two canals about three miles long at Joliet and Marseilles, and five movable dams and nine locks. The locks are to be 600 by 80 ft., with 14 ft. on the sills, and existing conditions are to be changed as little as practicable, thus avoiding damages

to riparian owners whether for power rights or for overflow.

A careful examination has been made of the detailed estimates presented by the State of Illinois. So far as concerns the engineering features alone, such as excavation, construction of dams, locks, power plants, etc., the estimated cost is reasonable. The State's estimate, however, includes nothing for flowage damages nor for the purchase of water-power rights and franchises, and should the outcome of judicial proceedings now pending cause these damages and rights to assume great value, the State's estimate would then be insufficient.

For purposes of navigation a diversion from Lake Michigan of less than 1,000 second-feet of water is all that will be necessary. For purposes of sanitation the works of the Sanitary District of Chicago were designed to allow the diversion of 10,000 second-feet and now contemplate a total of 14,000 second-feet, the additional 4,000 second-feet to be obtained by the diversion of water through the Calumet River and a connecting canal following the Sag route. The War Department, while awaiting the definite action of Congress, has so far permitted the diversion of 4,167 second-feet and the Sanitary District is understood to be using about 7,000 second-feet. As the water which is at present being diverted from the lake appears to have already seriously affected the navigation of its harbors and connecting waterways, prompt congressional action is recommended to limit the diversion.

While it appears to have been assumed that the Sanitary District may be allowed to divert 10,000 second-feet so long as actually necessary for sanitary purposes, the diversion of the waters of the Great Lakes from their natural outlet for power development alone is inadmissible, under the recent treaty between the United States and Great Britain. The future diversion of water from Lake Michigan for any purpose is fraught with difficulties. Not only has Canada an interest in the maintenance of lake levels which the United States must recognize, but every foot of water flowing through the Chicago Drainage Canal lessens the flow at Niagara Falls and at the power sites along the St. Lawrence River, where, due to the fall available, the same amount of water will create about four times the power that can be generated from it on the Des Plaines and Illinois Rivers.

The treaty enables riparian owners of Canada, as well as of the United States, who consider themselves injured by such diversion, to bring suit in United States courts to protect their interests. The claim that more than 1,000 cu. ft. per second is required for purposes of navigation cannot be maintained. The treaty, however, recognizes as proper the use of water for sanitary purposes, and it is the opinion of the Board that only such water should be diverted from Lake Michigan as is indispensable for sanitation, and then only with a provision for proper compensating works in the outlets of the lakes to prevent a lowering of their levels. Water thus diverted may be used incidentally for power purposes, but care must be exercised in authorizing the diversion of water for sanitary purposes, to restrict it to the amount necessary for those purposes alone.

The Board believes that the State is more generous in its provisions for navigation than necessity requires, that the locks it proposes are larger than will be utilized, and that if it constructed locks 600 by 80 by 11 ft., and reserved at each lock ground sufficient for an additional lock, it would fulfil all requirements, but it is also of the opinion that the State should be permitted to expend its own funds in such manner as it deems proper. With locks of the dimensions suggested by the Board, the $20,000,000 authorized to be appropriated by the State should complete this part of the waterway; and unless large expenditures are required for power rights, even the larger locks could be constructed for that amount.

Conditions Necessary in Connection With Cooperation to Fully Protect the Interests of the United States.

A primary condition of any cooperation between the United States and the State of Illinois should be the acceptance in perpetuity of full responsibility by the State of Illinois or its agencies for all damages by changes in lake levels, including cost of compensating works, and for all damages to riparian owners.

By this means the United States, at a relatively small outlay, can, with the assistance of the State of Illinois, make a test of the commercial value of an adequate inland waterway connecting Chicago with the cities of the Mississippi Valley. The plan of the State of Illinois to provide a navigable connection between the Great Lakes and the Mississippi River may be of such commercial value to the United States as to justify generous cooperation in its completion. The records of all previous investigations into the merits of such a waterway support this view.

There is no objection to the State's giving the channel such dimensions as it may consider advisable in order to preserve the head of water for power purposes, provided they are not less than those considered necessary for navigation. Increased widths and depths will be incidentally of benefit to navigation by diminishing the velocity with which the water will flow in the channel.

Plans and Estimates of the Cost of Work Recommended to be Done by the United States.

The existing Federal project for the improvement of the Illinois River, adopted in 1880, together with the existing State project, provides for a 7-ft. slackwater navigation from Utica to its mouth, which has been already obtained by dredging and by the construction of four dams, with locks 350 ft. long, and 75 ft. wide.

When this project was adopted the low-water discharge of the Illinois River was only about 500 cu. ft. per second at Utica and about 1,000 cu. ft. per second at its mouth. The opening of the Chicago Drainage Canal in 1900, however, radically affected the character of this stream, and has increased its low-water discharge at the present time to over 5,000 cu. ft. per second, and raised the level of low water so that 8 ft. can be carried to Grafton, provided that the upper miter sills at Henry and Copperas Creek are lowered about 1 ft., the crests of the dams are restored at the heights to which they were originally constructed, and portions of the pools deepened slightly by dredging.

While the present locks are smaller than the Board would recommend if new structures were to be created, they will efficiently provide for an extensive commerce, though large tows will have to be passed through them in sections. If a commerce should ever develop that would require the construction of larger locks, or a depth of 9 ft., the necessary locks can then be added.

Using the present locks, the estimate for an 8-ft. waterway from Utica to the mouth of the river, is as follows:

Excavation in pools and in river below Kampsville	$887,545
Lowering miter sills and reconstructing gates	60,000
Restoring crest Kampsville Dam	7,000
Miscellaneous and contingencies, 10%	95,455
Total	$1,050,000

Including new locks the estimate for a 9-ft. waterway, which may ultimately be required, is shown in the table at the bottom of the page.

The annual cost of maintenance below Utica is estimated as follows:

For an 8-ft. waterway:	
Four locks, at $10,000	$40,000
Dredging	25,000
	$65,000
For a 9-ft. waterway:	
Four pairs locks, at $14,000	$56,000
Dredging	35,000
	91,000
Above Utica: Five locks, at $10,000	$50,000

The report of the Board of 1905 for obtaining a 14-ft. waterway (H. Doc. No. 263, 59th Cong., 1st sess.) provides for a movable dam at Alton, and a canal on the east side of the river between Alton and St. Louis, considered necessary for such depth on account of the steep slope in the Mississippi River in the vicinity of the Chain of Rocks between St. Louis and the mouth of the Missouri River, the large amount of sediment in the Missouri River, and the extreme variation in the regimen of the river at this locality.

For an 8-ft. channel the main river can be utilized and the depths obtained by contraction works and shore protection as on the upper Mississippi and below St. Louis more cheaply than by a lateral canal. This will also allow to Missouri River boats free access both to the upper Mississippi River and to the portion of the river between St. Louis and the mouth of the Missouri River, which would be cut off by the Alton Dam. To obtain an 8-ft. depth, it is proposed to contract the river to widths varying from 1,250 to 2,100 ft. by a system of wing dams, to revet the caving banks, and to excavate through the Chain of Rocks a channel 500 ft. wide and 10 ft. deep at low water. The estimated cost of this work is:

ST. LOUIS, MO., TO GRAFTON, ILL.

Wing dams:		
Grafton to Missouri River, linear feet, 60,400, at $12.50		$755,000
Missouri River to St. Louis, linear feet, 26,500, at $25		662,500
Total for new wing dams		$1,417,500
Repairs to old work		150,000
Shore protection:		
Grafton to Missouri River, linear feet, 64,000, at $8	$512,000	
Missouri River to St. Louis, linear feet, 54,000, at $15	810,000	
Total for shore protection		$1,322,000
Rock excavation at Chain of Rocks, cu. yds., 138,000, at $3.50		483,000
		$3,372,500
Miscellaneous and contingencies, approximately 10%		337,500
Total		$3,710,000

The cost of annual maintenance is estimated at $125,000, including channel dredging.

A channel of 9 ft. depth can subsequently be obtained by dredging, at an estimated additional cost of $75,000 per year.

When the existing project for an 8-ft. waterway from St. Louis to Cairo is completed, it can be maintained at 9 ft. by dredging for an additional expenditure of $100,000 annually.

The work recommended by the Board in the near future, therefore, consists of enlarging the channel of the Illinois River from Utica to its mouth to 8 ft., at an estimated cost of $1,050,000, and providing an 8-ft. channel in the Mississippi River from the mouth of the Illinois to St. Louis, at an estimated cost of $3,710,000.

Until it obtains further data the Board defers its report upon the measures required to properly preserve the levels of the Great Lakes and to compensate so far as practicable for the diminished level in such lakes by reason of any diversion of water from Lake Michigan; upon the influence on volume and height of waters in the Mississippi River below Cairo; upon the effect upon the climate of the Lake States by a change in the natural currents of Lake Michigan; upon the improvement of the Mississippi between the mouth of the Illinois River and the mouth of the Ohio River by the construction of a dam at or near Jefferson Barracks, and a dam at or near Commerce, and the development of water power incidentally created by such dams.

Respectfully submitted,

W. H. Bixby, Brig. Gen., Chief of Engineers, United States Army; C. McD. Townsend, Colonel, Corps of Engineers; C. Keller, Major, Corps of Engineers; J. B. Cavanaugh, Major, Corps of Engineers; John Bogart, Civil Engineer.

Subdivisions.	Length in miles.	Excavation.	Locks.	Miscellaneous and contingencies.	Total.
Kampsville Lock to Grafton	31.5	$342,600	.....	$34,260	$376,860
La Grange Lock to Kampsville Lock	46.0	338,000	$519,000	85,760	943,360
Copperas Creek Lock to La Grange Lock	59.3	259,409	505,000	76,441	840,850
Henry Lock to Copperas Creek Lock	59.3	310,500	480,000	79,050	869,550
Utica to Henry Lock	35.0	417,800	468,000	88,580	974,380
Total	231.1	$1,668,909	$1,972,000	$364,091	$4,005,000

Resignation of Mr. H. E. Vautelet from the Board of Engineers for the Quebec Bridge.

The serious division of opinion in the Board of Engineers for the Quebec Bridge, over the question of which bid to recommend for acceptance, has now resulted in the resignation of the chairman, Mr. H. E. Vautelet, according to Canadian reports. The advisory experts appointed to settle the difference of opinion reported (as noted in Eng. News Feb. 16, 1911, p. 214) adversely to Mr. Vautelet's contentions. A summary of the whole matter is given by the Montreal "Gazette" of Feb. 24 in an article reproduced below; our information from personal sources enables us to state that the references to the history of the Board's work are substantially correct.

Mr. H. E. Vautelet has tendered his resignation to the federal Government as a commissioner for the construction of the new Quebec bridge. Mr. Vautelet, with Charles Macdonald and Ralph Modjeski, was appointed by the Government to do the work, but they had not proceeded far when it became evident that the trio would not be able to work harmoniously, the crisis coming when Mr. Vautelet differed with his associates over the designs which had been prepared for the construction of the great bridge.

The official design was mainly Mr. Vautelet's work and of course that gentleman supported not only his own plans but the tender of the British Empire Company which had been prepared on the so-called official design, all of which was opposed, however, by the two other commissioners, Messrs. Macdonald and Modjeski. When it became evident to the Hon. George Graham, Minister of Railways and Canals, and the officials of the department that the engineers could not agree, the deadlock was broken by the appointment of two extra experts, Messrs. H. W. Hodge, a New York bridge engineer, and M. J. Butler, Vice-President of the Dominion Steel Corporation. These two gentlemen went into the matters in dispute among the three members of the commission and came to the conclusion that th design prepared by Mr. Phelps Johnson, Vice-President and General Manager of the Dominion Bridge Co., aided by Mr. G. H. Duggan, Second Vice-President and Chief Engineer of the same corporation, and presented with the tender and on behalf of the St. Lawrence Bridge Co., was the best suited to meet the requirements.

In a word, the two additional experts decided against the contentions of Mr. Vautelet and in favor of those championed by Messrs. Macdonald and Modjeski.

It is understood that Mr. Vautelet's resignation was in the hands of the Minister of Railways before Messrs. Hodge and Butler came upon the scene, although the department evidently felt that some consideration would

have to be given to the subject before deciding to part with the services of so valuable a man as Mr. Vautelet. In the end, however, the resignation was accepted and it can be announced that a vacancy now exists on the bridge commission, although it is not probable that a successor will be appointed to Mr. Vautelet for some months to come.

Although the official award has not yet been made, it is fully understood that the contract to build the superstructure of the Quebec bridge will go to the St. Lawrence Bridge Co., of which Mr. Phelps Johnson is President and Mr. F. C. McMath Vice-President. As the last named is the President of the Canadian Bridge Co., of Walkerville, it will be concluded that a working organization between the two companies has been brought about for the purpose of building the Quebec bridge. It is said that the amount of the successful tender reaches somewhere between eleven and twelve million dollars. It is stated that although practically an independent construction staff will have to be organized, the efficiency of the Dominion Bridge Co. will not be impaired while the work on the Quebec structure is under way. The company have five years to complete the work, the actual time of construction being about three years. On the bridge which fell with so much loss of life the south shore end alone was under construction, but the new tender calls for both ends being carried on simultaneously, entailing a much larger staff.

A Bridge Renewal on the B. & O. R. R at Rowlesburg, W. Va.

By W. H. BOUGHTON,* Assoc. M. Am. Soc. C. E.

On Friday, Dec. 16, 1910, the old Baltimore & Ohio R. R. bridge over the Cheat River at Rowlesburg, W. Va., was rolled out and a new one rolled in. The actual time of rolling the bridges was 26 minutes, but traffic was held up for 4 hrs. 17 mins. The extra time was required for cutting the double-track connections to the old bridge, throwing the tracks to the new distance apart and connecting up to the tracks on the new bridge when it had been moved into position.

The old structure consisted of two separate single-track bridges each of two 160-ft. spans.

Fig. 1. B. & O. Ry. Bridge over the Cheat River at Rowlesburg, W. Va.; Old and New Spans Side by Side After the Change.

The new structure consists of two double-track spans instead. The view Fig. 1, taken after the transfer was made, shows the structures side by side.

Erection of the new bridge was begun last summer. At that time double rows of piles were driven on each side of the pier and on the river side of each abutment, extending upstream far enough to provide support for the new spans before moving and downstream far enough to provide support for the old spans after moving. The stone abutments were taken down and rebuilt of concrete to fit the new structure except that the back-walls were left to be completed after the transfer. The piles were capped and braced to form rigid trestles. On top of these were laid the roller tracks, each consisting of eight T-rails close together.

The rollers that ran on the track were 2½ ins. in diameter, 4 ft. 4 ins. long, and were held by side bars to a spacing of 14 ins. c. to c. The carriage that ran on the rollers consisted of two 9-in. I-beams extending under all three spans. Under each truss short additional I's were inserted to distribute the load over the whole length of a sufficient number of rollers. Under the old trusses blocking was laid up on these I-beam groups and it came about midway between panel points L0 and L1. The eyebars of the lower chord were of course unable as a beam to carry the weight of the bridge. At the shore ends, therefore, two 24-in. I-beams were set in place under the first two panel points and the blocking wedged up to them over the carriage as the end of the bridge was lifted by jacks. Thus the lower chord did not act at all as a beam. The hip verticals were stiffened by bolting to each one a 12 × 12-in. stick of timber. At the middle pier another plan was followed for

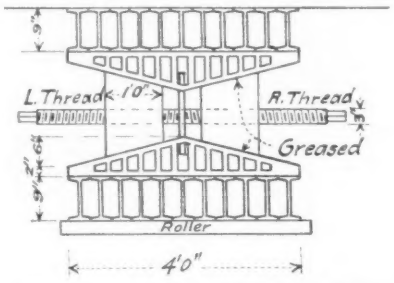


Fig. 2. Lowering Wedges for New Span of Rowlesburg Bridge.

the old trusses. There being a load on each side of the pier to be carried down to the carriage, the shoes of both trusses on one side of the bridge were set on a group of 24-in. I's running across the pier and resting at their ends on the blocking over the carriages.

The new spans were supported on the carriages in still another way, in order to provide for transferring the load to blocking placed under the shoes after rolling in. This arrangement, comprising wedges operated by a right-and-left screw, is sufficiently shown in the sketch Fig. 2. The same arrangement was used at shore ends and at the pier. The support had bearing up against the built-up lower chord of the truss; this chord, reinforced by 24-in. I-beams clamped to it firmly on top, carried the load as a beam. No reinforcement of the hip vertical was necessary in this case. After removal of these wedge supports, jacks were set in their places to adjust the bridge to its final resting place.

Neither the old nor the new spans had end floorbeams and therefore the end stringers were supported on the carriages by blocking wedged up.

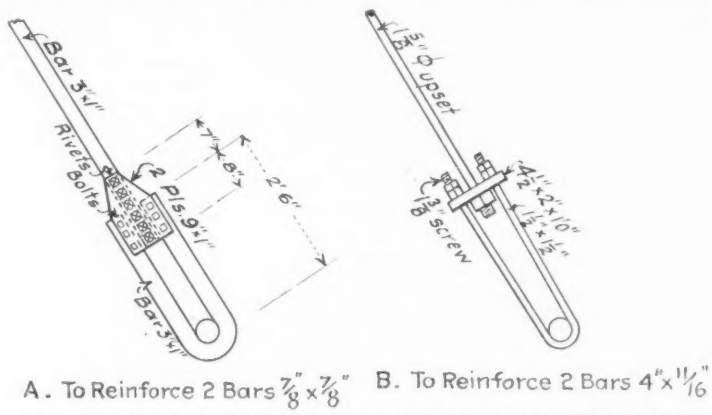
For power to move the bridge two hoisting engines were provided and set on the upstream side of the bridge, one on each side of the river. The blocks and tackle were in line with the carriages on top of the trestle downstream. Two movable blocks were hooked to each carriage and two fixed blocks to the piles at the end of the track. From each hoisting engine one 1½-in. hemp line was led around the near abutment and through the two pairs of three-sheave blocks in series, making twelve lines supporting the load; another line was led to the pier and through similar blocks there. This arrangement was not sufficient to start the movement, but a hydraulic jack was used at the upper end of each carriage to assist in starting. Track and rollers had been long covered with ice and it was necessary to clear away the snow again just before the moving.

It was important that all carriages move forward at a uniform rate and to check this an indicator was set up at the middle. A graduated vertical plank about 40 ft. long had a cross arm at the top about 8 ft. above the top chord of the bridge. A wire attached to one abutment ran up to the bridge, thence through pulleys along the bridge to the pier, thence up to the cross arm and down again to about the elevation of the floor where it was attached to one end of a steel bar about 6 ft. long. A wire from the other shore end ran along the other span and over the cross arm and connected to the other end of the bar. The movement of one end of the bar then recorded the movement of the corresponding shore end of the bridge and if both ends moved alike the bar remained level as it rose in front of the graduated plank. Another wire was stretched from the base of the pier to a pulley on the bridge, thence up to the cross arm and back to a connection with a weight hung even with the bar to which the other wires were attached. This served to show the movement of the pier ends where it could be compared with that of the shore ends. The distance rolled was about 35 ft. and the movement was nicely checked by this device.

These two structures side by side are interesting for another reason than the method of changing service from one to the other. They show strikingly the increase in loading that has been going on for railroad bridges since 1889 when the first of the two structures was built. Each of its four spans is of the pin-connected type, with eyebars for all main tension members and originally very slender counters. The laterals, both upper and lower, are tension rods. The new structure is riveted throughout, has no counters but stiff diagonals instead, and all laterals are stiff members. All this gives an appearance of rigidity that is not at all dispelled as one stands on the bridge while a train passes over. The contrast, in this respect, between the two structures is very great.

Of course the overloading of the old structure was known and some attention has been given to it. The counters, which would necessarily be most abused by an increase of live-load, have been reinforced. The method of doing this by adding members in panels with counters after the bridge was in service is shown in Fig. 3. The form shown at A was used in the middle panel to reinforce two ⅞-in. square bars, increasing the net section 137½. The form shown was used only at the lower chord points of this panel so that at the upper chord points the pins must have been driven back till the new member could be inserted. This could be done in the middle panel with only adjustable diagonals running to the upper chord panel points. But in the adjacent panels the form shown at B was used at the upper chord as well as at the lower. This form increases the section of the counter 38%.

The superstructure of the new bridge was fabricated and erected by the McClintic-Marshall Construction Co. of Pittsburg, Pa. The substructure work was done by the Youngstown Construction Co. of Youngstown, Ohio.



A. To Reinforce 2 Bars ⅞" x ⅞" B. To Reinforce 2 Bars 4" x 1 1/16"

FIG. 3. END CONNECTIONS OF REINFORCING COUNTER-BRACES USED IN THE OLD SPANS OF THE ROWLESBURG BRIDGE.

*Professor of Civil Engineering, West Virginia University, Morgantown, W. Va.

THE TOTAL COST OF THE FIELD WORK OF THE U. S. Census of 1910, so far as statistics of population and of agriculture on the Continent of the United States are concerned, was about $5,840,000. This was some 37½% more than was paid for the same work in 1900.

Annual Meeting of the Illinois Water Supply Association.

The third annual meeting was held Feb. 21 and 22 in the Engineering Building of the University of Illinois, at Champaign, Ill. The first session was opened about 2 p. m. on Feb. 21. Following the address of the President, Mr. C. E. Slocum (Belleville), an address on the subject of "Possible Lines of Service of the University to Municipalities," was given by Mr. David Kinley, Dean of the Graduate School. He referred to the importance of investigation and research work, and to the opportunities for collecting a fund of information available for the use of municipalities. He favored the enactment of laws for the regulation of public utility corporations, and these laws would be welcomed by the corporations provided they were fair and reasonable. He moved that a committee be appointed to draft resolutions endorsing such laws. Mr. D. H. Maury (Peoria), objected to this as not being proper action for the association to take, and he also doubted the wisdom of a small number of members adopting hastily prepared resolutions of this kind as representing the general opinion of the society. The motion was not carried.

A paper on "Rate Making," by Mr. F. C. Jordan (Indianapolis Water Co.), pointed out the great importance of this matter, upon which depends the success of a water-supply system. The rates must be sufficient to provide the operating expenses, maintenance, improvements, interest on fixed charges, and depreciation; also (for private corporations) a return on the investment sufficient to encourage capital to invest. The courts have held that it is both the right and the duty of a company to provide for depreciation. There should be no so-called "free" water, but each municipal department, etc., should pay its proportion for water furnished the city. Mr. Jordan was opposed to the meter system, and considered that if the city is properly informed in the matter it will agree to a rate that will be satisfactory. In the discussion one member took exception to the view that the rates should provide for a special return on the capital invested, the company being entitled only (in his opinion) to a return for its services.

A paper by Mr. T. C. Phillips (Chicago), on "Water Waste Surveys in Chicago," brought out some further discussion on meters. The paper set forth the view that such surveys or tests are more effective than meters in checking waste, but the opposite view was expressed by some speakers. Mr. Maury remarked that the author estimated 33% of the water pumped to be required for legitimate use, 33% for leakage at plumbing, and 33% leakage from mains. The failure of meters to check waste at Cleveland had been instanced, but the meter rates of that city were so arranged that much of the value of the meters in checking waste was lost. But meters in combination with a proper meter rate would effect the desired purpose.

Mr. C. B. Burdick (Chicago), presented a paper on "The Relation of Intakes to the Purity of Water from the Great Lakes." It is generally assumed that cities on the lakes have an abundant supply of good water available at low cost, but the paper showed the necessity of long intakes to avoid troubles due to turbidity, pollution, and the blocking of intakes by ice and sand or clay. The relative cost of long intakes and of short intakes, supplemented by filter plants, was discussed. Prof. S. W. Parr described some curious instances of the stoppage of steam pipes, the most interesting being a complete stoppage by ammonium salts in the riser of a steam heating system supplied by exhaust steam from a power plant. There was no return system, the condensation being discharged into the sewers. The water used was rather high in ammonia, and in the upper portion of the heating system considerable gas collected. Wherever the pipe was subject to a cooling influence there would be a tendency for condensation to take place, with consequent formation of crystals which eventually stopped the pipe.

The purification of water was treated in several papers. Mr. W. B. Bull (Chicago) described a new and simple electro-chemical method; caustic soda produced in an electrolytic cell is fed to the pump suction main, and at a little distance beyond an iron-chloride solution is introduced. The coagulation is very effective and the process is cheap, costing only about 45 cts. per million gallons. Prof. E. O. Jordan (University of Chicago) in a paper on "The Bacteriology of the Swimming Pool" described some experiments made in Germany as to the bacterial contents of the water in such pools, and the effect of hypochlorite treatment in reducing the bacteria to a minimum. Mr. Geo. N. Prentiss (Chemist of the C., M. & St. P. Ry.) described some experiments with the treatment of boiler water with barium hydrate. This is for use in cases where the amount of water used would not warrant the expense of a treating plant, the solution being delivered to the tender's tanks. Some experiments have been made also with the use of soda-ash in connection with the barium hydrate in order to reduce the cost of the latter. Mr. W. F. Monfort (St. Louis Water Department) presented a paper on "Experiments in Water Treatment with Ozone"; in regard to this process Mr. Maury (Peoria) remarked that while experiments have been made at different places it is generally held that the ozone process is not yet on a practical basis for use in the treatment of water supplies. Prof. E. Bartow presented an abstract of a paper by himself and Mr. H. P. Corson on "Analysis of Chemicals Used in Water Treatment."

Well water supplies received a share of attention, and the uncertain yield of drift wells was discussed by Mr. G. C. Habermeyer (Univ. of Ill.). Mr. E. MacDonald (Lincoln) presented an interesting paper on "The Condemnation of Land to Protect Wells," in which he referred to certain court decisions on the matter. Mr. L. Pearse (Chicago) called attention to the Long Island wells for the water supply at Brooklyn, N. Y.; many of these were sunk in submerged land, but when the operation of the wells had drained the land owners sued the city for "damages." Mr. F. C. Amsbary (Champaign) presented some notes on "Deep Well Pumps," and Prof. A. T. Talbot described a method for removing iron from a drift-well water. Other papers presented included the following: "Diagram for Friction Loss in New Cast-Iron Pipes," by A. N. Talbot and M. L. Enger (University of Illinois); "Fallacies in the Bacterial Control of a Sewage Purification Plant," Dr. A. Lederer and Frank Bachmann (Chicago), and "The Sewage Problem in its Relation to Water Supply," by Langdon Pearse.

Officers for 1911 were elected as follows: President, Owen T. Smith (Freeport Water Co.) Freeport, Ill.; Vice-Presidents, R. R. Parkin, Elgin; C. H. Cobb, Kankakee, and H. M. Ely, Danville, Ill.; Secretary, Edward Bartow, Director of the State Water Survey, Urbana, Ill.

The Development of Paint Formulas.*

By L. S. HUGHES.†

Until very recent years there was no technology of paints worthy of the name; in fact, it is not too much to say that there was no understanding of the causes of success or failure of any formula. It was recognized in a vague way that a zinc paint was likely to peel, and that the addition of non-drying oils led to difficulties; and certan pigments were accepted as valuable, but the art of combining the various available materials was purely empirical; each formula was tried out without co-ordination of its results with the results of other mixes.

The reasons for the long persistence of this condition are not hard to recognize. First, there were no comprehensive or reliable methods for the testing of either pigments or paints. Chemical analyses, even when correct, failed to account for the wide discrepancies observed in the behavior of paints of similar chemical composition, and this method of examination fell into total disrepute among a majority of painters and paint manufacturers. Second, there was a widespread feeling that the value of a paint was in some occult way proportionate to the cost of the raw materials. Indeed, this curiously illogical idea is, even to-day, so widely spread that it is the basis of advertising by many large manufacturers. The third and last of the important factors in delaying the development was the very general fraud practiced for the purpose of taking advantage of the belief just mentioned—the manufacture and sale of paints under secret formulae and their sale under guarantee of containing nothing but recognizedly expensive pigments. As some of these mixtures, very largely cheapened in cost by the addition of native mineral pigments, were far superior to their nominal composition, it necessarily followed that the latter obtained the credit, and so the advantage of "purity," i. e., freedom from anything except white lead and zinc oxide, became a very general criterion of excellence.

So long as this general misrepresentation continued, and there was no certain method for testing a paint save by using, it is not unnatural that paint-making failed to become subject to proper technical control. At last, however, some large manufacturers, especially those who manufactured paint for their own use, and some independent chemists began the practice of subjecting all raw materials to regular and thorough examination. At first the data were of little value except in securing uniformity in suply, but as the microscope came more and more into use, conjointly with improved chemical methods, it became apparent that structure and size of particle were of no less importance than chemical composition. Further, the fact began to receive recognition that all of the natural pigments suitable for use alone (or "straight") were heterogeneous in size and almost invariably so in structure.

This was at first misinterpreted into a rule which, while it contained the elements of an important truth, was nevertheless inexact as stated. The rule at first was that the finer the pigment portion of a paint the better. To prevent possible misunderstanding, it is perhaps advisable to anticipate a little and to say here that the more modern form of this dictum is that the finer the major pigments in a paint the better, but that there is advantage in the presence of a moderate portion of distinctly coarser particles.

The apparently mysterious fact that the addition of transparent crystalline ingredients to most of the opaque pigments improved the hiding power of the latter proved a stumbling-block for a long time, but was finally elucidated by a demonstration that showed this to occur only when the transparent materials were coarse enough to afford points for capillary action, thus increasing the thickness of the coat. It naturally followed, and, indeed, was proved, that the diameter of the larger particles was coincident with the thickness of the coat.

These two points were of no little importance, because they established a sharp differentiation between "opacity" and "hiding power," two characteristics which had been badly confused and generally regarded as identical.

These investigations were accompanied by coincident interpretations of the chemical behavior of the various ingredients. At first this concerned itself only with the behavior of the straight pigments, and the results found expression in many hopeless contradictions. As an instance, because silica, barytes and other crystalline carths of manifest chemical inertness failed entirely when used alone, the erroneous idea grew up that unless a pigment were sufficiently basic to react with the oil of the coat it was of doubtful value. As a matter of fact, the preponderance of evidence was enormously on the other side from the recognized superiority in wear of the demonstratably stable iron oxides, many dry colors and especially of the totally non-reactive carbon pigments. The difference in color of these from the white pigments was apparently the reason for their lack of consideration—a thing which to-day seems so totally inadequate as to approach the incredible.

Many paint men were never satisfied of the correctness of this belief, but it was so generally accepted as to lead to legislative action by one State in the form of a law which directly encouraged paints made only from basic lead carbonate and zinc oxide, two highly reactive pigments. The phrasing of this act indirectly stigmatized all other ingredients as adulterants.

Even at the time of the passage of this law a consideration of the previously disregarded data of the wear of inert colors and a recognition of the value of the comparatively new basic-sulphate white lead had led to a grave suspicion that saponification and analagous reactions were not only of no benefit, but were emphatically destructive.

This view spread rapidly because the micrographic study of paints furnished a complete explanation of the failure of the stable crystalline pigments when used alone. Their noticeable coarseness and the universality with which their amorphous analogues proved successful needed little interpretation to show that it was not the chemical stability of the crystalline materials which caused their failure when used alone, but that their angular outline and absence of small particles gave a coat possessing interstices of appreciable dimensions, and these being filled with nothing but the easily perishable "linoxin," afforded little resistance to weather attack. Addition of impalpable amorphous substances entirely remedied the weakness of the crystalline pigments ex-

*An address read before the Chicago Section, American Chemical Society, Dec. 16, 1910, printed in the society's "Journal of Industrial Engineering Chemistry," January, 1911.

†Joplin, Mo.

cept in so far as their undue proportion limited the area covered by the paint.

The work of the late Dr. Dudley and others outlined the general means by which the permeability of a paint coat by moisture and gases may be controlled and the necessity for heterogeneity of structure and composition became very generally recognized.

Satisfactory demonstration of the applicability of these various principles proved of no little difficulty, largely because there was little cooperation between the different experimenters and partly because of what appeared to be hopeless discrepancies between the record of exposure test of analogous formulas in different localities. In a general way it had been acknowledged that a given formula was better adapted to certain classes of work and locality but there was a strong underlying opinion that a really good paint would be successful under any conditions.

It is easy to be wise after the fact, but in the present light of the very comprehensive and valuable records of the cooperative test fences the local success of many paints contrasted with their failure outside of the range of the climatic condition prevailing at the factory where they were tested and developed would seem necessarily to have suggested the necessity or at least the desirability of adjusting formula to climate. It is true that suggestions toward this end have been made, but they are merely tentative.

It remained for Mr. John Dewar, in his valuable review of test fence records, to make the declaration that no one formula can prove satisfactory under all climatic conditions. This dictum is the latest in paint development, and with it we may properly close a recital of the gradual development of paint-making rules and turn briefly to a consideration of their application to the use of those pigments which are in general use.

ATLANTIC CITY AND PITTSBURG TESTS. — The records of condition of the white pigments used straight, as developed by their exposure at Atlantic City, is instructive in illustrating the fallacy of the doctrine of "purity" as a criterion of reliability. The three types of basic lead carbonates showed "bad condition"; zinc oxide showed "fair condition"; the sublimed or basic-sulphate white lead and the zinc-lead showed records of "good condition."

These tests were closely confirmed by the exposures at Pittsburg, although the character of wear in the two sets of tests was naturally quite different.

The remarkable consistency with which the fumiform or sublimate pigments outlasted their pulverized and precipitated competitors is strikingly indicative of the benefit of impalpable fineness and amorphous structure in the major pigment of a mix.

Without exception the individual pigments showed improvement in behavior when employed mixed with others; the prohibitive hardness of the zinc oxide coat was greatly modified by addition of either of the white leads; the checking of the lead carbonates and their tendency towards discoloration were diminished by large admixtures of either zinc oxide or crystalline ingredients, while the sublimed or basic-sulphate white lead, which (like all the straight leads) exhibited a soft coat, was satisfactorily hardened when tempered by the addition of zinc oxide.

The recognized difficulty of securing satisfactory brushing with fumiform pigments only proved easy of elimination by the employment of small amounts of coarser and crystalline pigments. Most satisfactory of all, perhaps, was the demonstration that the characteristics of a pigment persist in mixtures and are manifested proportionately to its amount therein.

A complete demonstration of the advantage of modifying the faults of one pigment by mixing it with others of different qualities is at least strongly indicated by the record of six out of seven successful exposures of paints containing four pigments each.

So consistent was the improvement noted with increasing heterogeneity that the committees in charge of the experiment have made unqualified declaration of the superiority of formulas containing both lead and zinc in addition to mineral crystals.

NORTH DAKOTA TESTS.—Attention so far has been given only to the tests at Atlantic City and Pittsburg, because the climatic conditions to which they were exposed are representative of much more important areas than the other series of public tests—those at Fargo, North Dakota.

That the latter have confirmed the generalizations of the Eastern tests is best shown by quotations from a report on the Fargo fences:

> It was conclusively demonstrated that mixtures of white lead and zinc oxide, properly blended with moderate percentages of reinforcing pigments, such as asbestine, barytes, silica and calcium carbonate, have proved most satisfactory from every standpoint, and are superior to mixtures of prime white pigments not reinforced with inert pigments.
>
> The white leads painted out on the 1908 fence exhibited different degrees of checking; the mild process lead and sublimed white lead, which presented the best surfaces, were free from checking, while the old process leads seemed to be showing very deep and marked checking, even after one year's wear.*

While the generalizations were thus borne out by the Dakota tests, it must be said that the limits of usefulness of the various "prime" (or opaque) pigments were differently indicated. In the sea coast and Pittsburg tests, very little trouble was noted in securing satisfactory adherence to the painted surface; the difficulty seemed to be to prevent undue permeation of the film by destructive gases and vapors—a problem most satisfactorily solved by the employment of the excessively fine fumiform pigments. As the humidity was always fairly high in these exposures, the brittleness, due to hard coats with consequent splitting or peeling, was not noticeable.

In North Dakota, however, the aridity and wide range of temperature almost reversed the problem, and while very few coats perished by disintegration, many paints failed through lack of adherence and the through undue hardness. The high-lead mixes, with their consequent softness, proved best, and the advantage of reducing the zinc-oxide content for this region was demonstrated.

A universal improvement in wear was observable in the tinted paints over the untinted made from the same "white base" in all tests, without regard to locality—a difference so marked that it is doubtful whether it can be entirely accounted for by consideration only of the increased proportion of chemically stable pigments and the necessary increase in heterogeneity of structure. It appears probable that explanation must await a better understanding of the effect of light within the paint film.

These various tests, confirming, as they do, previous research, bid fair to put paint compounding upon a proper technical basis.

The formulae of to-day can be compounded to secure definite permeability, definite hardness (by proportioning the lead and zinc pigments) and certain attachment to a surface, either by use of a chemically stable fumiform pigment of sufficient fineness to enter the pores of wood or through insuring a soft coat by avoidance of zinc or other hardening agents. Thickness of coat can be accurately controlled by the amount and size of crystalline pigments employed, and checking or internal disintegration can be avoided by the selection of non-reactive and insoluble pigments. Indeed, it is not too much to say that the major functions, at least, of our available pigments have been accurately catalogued.

While much remains to be done (especially in improving the vehicle), the rapid progress that has been made in developing a scientific basis for paint compounding must be regarded not only as satisfactory, but as gratifying.

*Bulletin 25, Scientific Section, Paint Manufacturers' Association, p. 9.

The Interstate Commerce Commission's Decision on the Advances in Freight Rates Proposed by the Railway Lines East of the Mississippi River and North of the Ohio.*

For several years past railroads have been insisting that owing to the enhanced cost of operation, freight rates must be increased, and in the early summer of 1910 tariffs were filed naming such increases upon all class rates and upon about one-half of the commodity rates within the Official Classification territory.

An Act of Congress which took effect June 18, 1910, conferred upon the Commission jurisdiction to institute upon its own motion proceedings of inquiry into the reasonableness of rates. Acting under this provision the Commission, on July 13, 1910, instituted this investigation.

These advances in railway rates are justified upon the ground that the cost of operation has so increased that although gross operating income has continued to grow the net operating income has become and is insufficient. The question presented to us is, Are these defendants justified in laying this additional transportation burden upon the public for the purpose of obtaining greater net revenue?

Assuming that the rates of a railroad are to be so adjusted as to allow it a fair return upon the value of its property devoted to the public service, the first inquiry should be, What amount is this railroad entitled to earn? When that amount has been fixed there arises the further inquiry, From what source shall this revenue be derived?

A railroad is ordinarily a carrier of both freight and passengers and of many kinds of freight. Now, how much net return ought its passenger business to yield and how much should be contributed by each kind of freight? This problem is greatly complicated by the further consideration that certain kinds of traffic will not move at all unless a certain rate is accorded, while the movement of other kinds of traffic is but little affected by the amount of the transportation charge.

The railroad rates of this country have not been constructed as a rule upon any scientific basis, and this is especially true of the interstate rates. The traffic officials who have established these rates have generally done so without any special inquiry as to the total amount of revenue which ought to be produced or as to the part of that burden which a particular commodity ought to bear.

It is now the settled law that there is a limit below which the revenue of railways cannot be reduced by public authority, and if there were no such constitutional limitation it would nevertheless behoove every regulating body to permit the existence of such rates, when possible, as will yield just earnings to the railway.

The Effect of an Increase in Rates Upon Various Interests.

Since the beginning of this proceeding great numbers of letters and petitions have been presented from individuals, organizations, and committees representing various interests, some urging that these advances be sanctioned, and others protesting against them. It seems to be the popular impression that this is in some sense a political question, which may properly be disposed of in accordance with the wishes of the majority.

The railroad freight rate affects all classes of society, but in different ways. The investor in railroad securities desires that the rate be liberal in order that the integrity of his security may be protected. The railroad employee believes that the rate should be advanced, since if his employer has ample earnings he can obtain a larger share for himself in the way of increased wages. The railroad supply house approves the advance because higher rates insure better business for it.

Upon the other hand, the manufacturer insists that higher rates mean to him a higher cost of production and less profit in the operation of his factory. The merchant urges that to increase the transportation charge is to increase the cost of his commodity and to limit the amount of his sales.

It should be noted moreover in this connection that those who are most affected by these advances are usually not represented at all in such discussions. While it is true that the increased rate adds to the cost of production and while at the outset this increased cost must perhaps be borne by the manufacturer or wholesaler, still in the end the freight rate, like every other item of expense, finds its way into the price paid by the consumer.

It was objected in the course of these hearings that the interest of the general public in the proposed advances was but slight, since the additional transportation charge as applied to a single article would be practically negligible, but the deduction sought to be made from this fact cannot be allowed. Whatever is added to the net revenues of these defendants must be paid by some one. An increase of 1 cent per ton in the rate of transportation would hardly be perceptible in case of any commodity, and yet 1 cent per ton upon the total tonnage of the railroads of the United States, as shown by the returns to this Commission for the year 1909 would amount to $8,264,927, which forcibly illustrates the necessity of scrutinizing every advance, no matter how slight.

This Commission must stand for the entire public, including the railways. It cannot accede to the mere wish of any class; it must recognize the just demands of all classes; and it must have in mind those who do not appear as well as those who are represented before it.

The Effect of Increased Freight Rates in Stimulating Business.

A somewhat different question is presented by those who urge that to permit these advances in freight rates would immediately stimulate all kinds of business. The assumption appears to be that business conditions are unsatisfactory, and that some special effort is necessary to restore satisfactory conditions.

The thought seems to be that to permit these advances would induce larger expenditures in the maintenance of our present roads, and would lead to extensions and improvements which would in turn employ additional labor, put into circulation additional money, and thereby improve general business conditions.

So far as such expenditures are legitimate, they ought to be encouraged. Necessary extensions and improvements should be made, and the treatment of our railroads by the public should be such as will inspire that confidence in the investing public necessary to obtain the funds for such additions. But to the extent that an artificial impetus might be given to railroad building and kindred industries, the effect would be in the end baneful, even though the temporary result might seem beneficial.

It appeared upon this hearing that the freight tonnage of 1907 was larger than ever before, that this led to an unprecedented demand for railway equipment and railway supplies, and that factories were then provided to meet this demand, which cannot now be fully utilized. It was admitted by the representatives of supply houses that the productive capacity for railway equipment and supplies much exceeded that required for the ordinary upkeep of our railways, and that these facilities could only be utilized to their full and most profitable extent in case additional railroads were constructed and additional equipment required. We ought not to impose upon the public rates, otherwise unreasonable, for the mere purpose of temporarily providing

*The decision, which was prepared by Commissioner Prouty, is far too lengthy a document for publication in full. What is here given is extracts containing the main points made by the Commission, particularly those of interest to engineers.

business for these factories, even though the effect might be to stimulate, for the time being, other kinds of industry.

Is an Increase in Rates Necessary to Make Railway Bonds Salable?

We are told that this increase in rates is necessary to maintain the credit of our railroads, and this claim has been made by high authority and with much insistence. It is said that our railroads owe at the present time large sums which are being carried upon short-time paper and which should be converted into funded indebtedness; that other large sums must be had in the immediate future for necessary extensions and improvements; that the money for these purposes should come largely from foreign investors, since the rate of interest in England and upon the Continent is lower than with us, but that, at the present time, there is, owing to the treatment of our railroads by the nation and by the various states, a feeling of distrust which has impaired the selling qualities of their securities, and which should be removed by a decision of this case in their favor.

It may be admitted that it is for the interest of the general public, as well as the railroads, that their funded debt should bear as low a rate of interest as possible. A very considerable part of the saving to railway companies in recent years has come from a reduction in the rate of interest paid. In 1895 the average rate paid by all the railroads of this country was 4.69%; in 1909 this figure had been reduced to 3.90%, and the saving computed upon the indebtedness of 1909 represented by this decrease in the rate of interest would have amounted to $77,000,000.

This record does not indicate that railway credit has been impaired. It does appear that it is impossible to sell a 4% bond at the same price to-day which the same bond would have brought ten years ago; but this by no means shows that the reason for the reduced price is want of confidence in the security. A municipal bond, into the value of which the quality of the security does not enter, sells in the year 1910 for a materially lower price than the same bond brought in 1900. The price of a railroad bond is better to-day, as measured by the price of a municipal bond, than it was ten years ago, and this would indicate that in the last decade the credit of our railways had gained, not lost.

As to conditions abroad no reliable information is before us. Whatever unfavorable impression prevails is due largely to the activities of the railroads themselves. Never before have the net earnings of the railroads of the United States equaled those for the year 1910, estimated on any basis. Never before has the gross amount paid in dividends been as large as in the year 1910; and yet in the face of this unparalleled prosperity the press both at home and abroad has been filled, through railroad influences, with dire forebodings of coming disaster. If railroad credit is still sound, either at home or abroad, it is not because of but in spite of the declarations of railroad operators.

We have an impression that the trouble with American railway securities in foreign countries has been in the past, and may be to-day, not too much Government regulation, but rather the want of it. Practices like those which have disgusted the foreign investor with American railway stocks and bonds in many instances would have been impossible under proper governmental supervision. When the foreign investor understands that no dollar of stock or of bonds can be issued without the sanction of the Government and that every dollar of the proceeds from the sale of stocks and bonds must be invested in the property against which his security stands, his confidence in the American railway list will be increased rather than diminished.

But, however all this may be, a fundamental economic fallacy underlies the proposition that we should permit rates otherwise unreasonable for the purpose of bolstering up the credit of our railways. It would be much better for the Government to guarantee these bonds than to permit the people and the industries of this country to bear the burden of unreasonable transportation charges.

Does the Increase in Railway Employees' Wages Justify an Advance in Rates?

The carriers in this proceeding seek to justify the proposed advances by showing an increase in cost of operation due to certain increases in the wages of their employees. The item of labor makes up nearly one-half the total cost of the operation of a railroad. In the spring of 1910, consequent upon the demands of various labor organizations, wages were generally advanced in Official Classification territory. These advances were not uniform in all classes of labor, nor upon all lines, but they aggregated from 5 to 8% of the pay rolls of most of the railroads involved and were therefore very substantial in amount.

There are 41 principal operating companies in the territory involved. Taking the 41 railroads together, the increases in wages for the year 1909 would have amounted to nearly $35,000,000, while the additional revenue from the proposed advances would only have been $27,000,000.

The defendants, or some of them, insist that upon that showing and without further inquiry we ought to suffer the advanced rates to take effect. Individual rates might be attacked by individual shippers, but the proposition that a general advance might be made has been established.

It seems apparent that the carriers have not, by showing that the increases in wages more than equal the increases in rates, made out the reasonableness of the proposed advanced rates. During the year ending June 30, 1910, the net earnings of these railroads aggregated $51,000,000 more than during the year 1909. If, therefore, the entire advances in wages had been in effect during the whole year of 1910, instead of during a few months in the spring of that year, the net earnings for 1910 would have exceeded the net earnings for 1909 by $16,000,000. This is not conclusive against the propriety of these advances, for the earnings of 1909 may have been too small or the causes which contributed to the greater net earnings of 1910 may not be permanent in effect; but it does show that we cannot conclusively presume from an increase in operating expenses that there should be a corresponding increase in transportation charge. It is the net, not the gross, which we must consider.

What Is a Reasonable Railway Rate?

The question, then, is, To what net earnings are these carriers properly entitled? The courts have often said that a public-service corporation is entitled to a fair return upon the value of its property being devoted to the public service. While this language has been used in connection with proceedings to determine the point below which the revenues of public-service corporations may not be forced by legislative action, it states a rule of general application. Both the value of the property and what is a fair return upon that value must be considered.

Some states have authorized and even instructed their railway commissions to put a value upon the property of railways operating within their borders. In some instances the elements to be considered in determining that value have been prescribed by statute, and the effect of the valuation when made is indicated. This Commission has no such authority. Nevertheless we must have a general notion of the value of the properties of these defendants and must form an idea of the elements which should properly enter into the determination of that value.

Here we have the benefit of the judgment of the Supreme Court of the United States. In Smyth v. Ames, 169 U. S., 466, that court had before it a statute of the state of Nebraska fixing certain maximum freight rates, the question being whether those rates were so low as to be in violation of the fourteenth amendment. In disposing of the case the court elaborately considered the relation of value to a reasonable rate. The law as there stated has never been qualified.

> We hold, however, that the basis of all calculations as to the reasonableness of rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public. And, in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stocks, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses are all matters for consideration, and are to be given such weight as may be just and right in each case. We do not say that there may not be other matters to be regarded in estimating the value of the property.

While the court enumerates the factors which should be considered in the determining of the value of the property no attempt is made to assign any definite value to these different factors, and counsel who have argued this case both for and against the advances are hopelessly divided upon this point. We may point out here the extent to which the present record contains information upon each of the various elements of value embraced in the above enumeration by the court.

The first two elements—original cost of construction and permanent improvements—may be considered together.

Carriers are now required to state in their statistical returns to the Commission the cost of their properties. If this account were correctly kept it would show the money expended from the first in building and equipping the railroad.

In point of fact, this item is not reliable. The present railroad systems in Official Classification territory have usually been formed by the combination of a large number of smaller railroads, which were built as independent properties. The Baltimore & Ohio system, for example, embraces more than 100 properties which were originally independent. The only information which the present system has of the original cost of construction is that derived from the books of the various companies which have been absorbed. These books were seldom accurately kept and often represent as money what was, in fact, something else. The beginnings of this account, therefore, are very imperfect and unreliable.

Were it possible to determine the exact amount of money which has been put into these properties, the amount of return which has been paid up to the present time, the degree of prudence with which the property has been constructed and operated, certainly the investment would furnish a very satisfactory basis for arriving at an equitable return. But these facts never can be determined with accuracy. We can not know even the actual amount of money which has gone into these enterprises from outside sources, nor the return which has been paid upon it, nor whether reasonable diligence was exercised in the investment or in subsequent management. Disaster may have come upon it, for which the public ought not to stand accountable. This factor must be more or less controlling, according to the circumstances of each individual case.

The Rights of Investors in Railway Securities.

The third factor named by the Supreme Court is the amount and market value of the stocks and bonds. This information can be obtained with great accuracy, covering both the present and a considerable number of years, but no counsel in argument has attached any importance to the information when obtained. In this feeling we do not altogether share. It seems to us that the price at which these stocks and bonds sell may be a matter of some significance in determining the amount which the railroad should be allowed to earn.

We are not fixing the value of a collection of ties and rock and steel rails, but of a railroad equipped and doing business. What is that railroad worth as a railroad for the transaction of a railroad business?

Most of the great systems in Official Classification territory have existed in substantially their present form for the past 25 years. While there is to-day no competition worth the name in the railway rate, and while there never will again be such competition, this has not been true of the past. Originally there was the most active competition in the rate of transportation by rail, and these tariffs, especially in Official Classification territory, are largely the product of that competition. There is a strong presumption that rates so arrived at are reasonable rates. Now, the market value of the stocks and bonds of each of these carriers represents the sum which that property will bring in the open market.

There is another aspect in which this stock and bond factor is important. The Government has invited private capital to invest in the construction and operation of these public utilities. While it might have established the rate, it has left that to competitive forces. We are told upon the hearing of the extent to which savings banks and insurance companies held the securities, especially the bonds, of these railways. We know that private investors have bought, not for speculative purposes, but as a legitimate and permanent investment, large amounts of the stocks of many of these companies.

Now, this Government having permitted this to be done can not close its eyes to the fact that it has been done. We can not be oblivious to the effect of our action upon the value of these investments, which have been made in good faith. In this view the market value of these stocks and bonds for the last 10 years certainly, and the effect which our action may have upon their market value for the future, must be considered. We can not, of course, allow such rates as will in all cases guarantee or perpetuate the prices at which these stocks have been bought, but in viewing the entire situation we should have that price in mind.

Physical Valuation of Railways.

The next item named by the Supreme Court is the present cost of reproduction. This is undoubtedly a factor of great importance in determining the value of the railroads of this country, upon which earnings may be legitimately demanded. The courts have repeatedly recognized this in their decisions touching the rates of public-service corporations. Many states have authorized a physical valuation of their railroads in this view. This Commission has several times urged Congress to take steps looking to such a valuation, but up to the present time this has not been done.

It was insisted upon the argument that this was the only test of value entitled to serious consideration, and we were urged to postpone our determination of these questions until such valuation could be made. In view of the fact that the Supreme Court has not yet apparently held that the present cost of reproduction furnishes the only measure of value, and especially in view of the refusal of Congress to act upon the suggestion of this Commission by taking steps to procure such valuation, it would seem to be our duty to proceed with the disposition of this case as best we can upon the present record.

The last item is "the probable earning capacity of the property under particular rates prescribed by statute and the sum required to meet operating expenses, which means, information necessary to determine the net revenues which will accrue from the application of particular rates.

This information the Commission has.

The foregoing are the factors which, in the opinion of the Supreme Court, are to be weighed in determining the value of these properties for rate-making purposes. When it is remembered that information upon one and perhaps the most important of these heads is entirely lacking, that the Supreme Court itself has not attempted to assign a particular value to any one of the above

factors, which must be combined to produce the result, that counsel after the most careful consideration, both of the law and of the economic and social problems which underlie this subject, are hopelessly divided as to the relative importance of these respective items, it will be seen that anything like a mathematical conclusion or one for which a definite reason can be assigned is impossible.

We must take the history of these properties and, from a consideration of all the facts before us, arrive at some rough notion of their value for railroad purposes. As a part of that same inquiry we must form some idea of the rate of return to which the property of these carriers is entitled.

What Is a Fair Return on Railway Capital?

In discharging our duty to say whether these particular rates which the carriers propose to establish are just and reasonable we must determine in a general way what a fair return would be.

It now is and long has been the settled doctrine of our courts that the railway is a public highway. The fair inference from those decisions is that the Government may, through the states or the Nation, if the Federal Constitution be broad enough, construct and operate these public utilities, or it may delegate that duty to private individuals. In case the railroad is operated by private capital, the Government may prescribe the rules under which the public service shall be discharged and the rates which shall be charged for that service, subject to the constitutional limitation that the private property shall not be deprived of a due return.

Outside the United States a majority of railroad mileage is to-day owned and operated by the Government. It has been our policy from the first to delegate this duty to private individuals, and in this way a vast amount of private capital has been induced to invest in railroad construction and operation.

Now, the ordinary considerations of justice require that the money so invested by invitation of the Government should be allowed a fair return. This does not mean that we should permit rates which will guarantee all railroad investment, nor which will guarantee any railroad investment at all times, but we should allow rates which will yield to this capital as large a return as it could have obtained from other investment of the same grade. If rates formerly in effect have become insufficient, then higher rates should be permitted.

Our railroads must be maintained in a high state of efficiency. This the public interest demands. Commerce and industry can not afford to wait on transportation facilities. Our rates should be such as to render possible a high-class, not an extravagant service.

It is generally conceded that within the next few years, if our means of transportation by rail are to keep pace with the calls upon them, very large sums must be expended in the way of new construction and new equipment. While some small portion of this may come from current earnings, the great bulk must be new capital. This capital must be obtained from the investing public. If, therefore, we are to rely in the future, as we have in the past, upon private enterprise and private capital for our railway transportation, the return must be such as will induce the investment. It is therefore not only a matter of justice, but in the truest public interest that an adequate return should be allowed upon railway capital.

At the same time the railway rate is, in the final analysis, a tax laid upon nearly every species of property and upon almost every sort of activity, and there is no reason why all other kinds of property should be required to pay to this particular species of property an undue compensation.

These statements are truisms; the real inquiry is, How much! Upon what considerations can we determine the figure which is necessary to do justice between the private capital operating our railways and the public using those railways?

The element of risk is less here than in most industrial operations. In private enterprise there is continual danger of competition. No matter how well established the business, nor how profitable the present return, there is always the hazard that some other article may take the place of the one produced, or that some other factory may produce the same article at a less price. This possible competition imperils the existence of the investment itself as well as the annual return.

No such consideration enters into the business of the railroad, certainly not of these railroads before us. The main lines of railroad in Official Classification territory have been constructed, and there is but little danger to be apprehended from the construction of new lines. There must be extensions and additions, but these will be along and in connection with the present trunk avenues.

There is but little competition in the price at which the commodity produced by these railroads, viz, transportation, is sold; that is, in the rate. This was not always so. In the past the most violent competition in railway rates has prevailed, and this competition has often gone to the point of imperiling the financial integrity of great railroad systems; but all that is a thing of the past. The law itself practically forbids it, and if it were permitted by law it is inconceivable that the practices of former years would recur.

What business can be more attractive to the investor than this, in which no rival is to be apprehended, where the amount of business is assured, and where the price for the transaction of that business is protected by the fundamental law of the land.

All this has long since reflected itself in the prices of railway securities. Ten years ago a high-grade, long-time railroad bond like the 3½% New York Central underlying mortgage sold at par. To-day, owing apparently to the increase in the rate of interest a similar bond, in order to bring par, must bear a rate of 4%, or perhaps slightly more. These railroad bonds command nearly as high a price when no question of local taxation intervenes as do municipal bonds.

The price of railroad stocks in the past has not been controlled by the same considerations as that of railroad bonds. These stocks have been largely the subject of speculation and the prices have been determined by other considerations than the mere rate of dividend. These conditions are changing. In Official Classification territory the day of railroad construction and railroad consolidation has given place to that of railroad operation. The successful railroad magnate of the future in this territory will be he who can operate his properties most economically and most satisfactorily.

Under the conditions of the future, railroad stocks, or at least the stocks of these railroads before us, are bound to lose much of their speculative character and to assume more the character of an investment. To-day a 5% non-cumulative preferred stock sells for slightly more or slightly less than par, according to conditions. At its present market value the 4% preferred stock of the Baltimore & Ohio yields a return of about 4½%. It seems probable that any railroad stock which was certain to pay a dividend of 5% year after year would sell readily at par.

[Concluded in our next issue.]

A Steel Arch Bridge to be Built Over the Panama Canal Cut at Empire.

Recent reports from the Canal Zone indicate that a steel arch bridge of rather large size will be built to replace the present suspension bridge at Empire (built two years ago, as described fully in our issue of Dec. 16, 1909). While the suspension bridge is ample for light roadway traffic, it is not considered to be a permanent structure, and in any case cannot carry railway trains. The Commission desires to provide for carrying the Panama R. R. over the canal at this point. A Board of Engineers was appointed recently to consider the subject of a permanent bridge; its report is abstracted in the "Canal Record" of Feb. 8, 1911.

The Board was composed of Lieut.-Col. H. F. Hodges, Lieut.-Col. D. D. Gaillard, H. H. Rousseau, J. A. Smith and Lieut. Frederick Mears. The general conclusions reached were that a permanent bridge over the canal cut at Empire is necessary and desirable, and that such a bridge should be a fixed high-level bridge. The clearance height to be provided was not decided upon definitely, but the Board found that a least clearance of 150 ft. is needed by existing steamships, and therefore selected a clearance height of 175 ft. as sufficient for purposes of estimate.

The location of the new bridge would be at or very near the site of the present suspension bridge, preferably either just north or just south of the latter. The cross-section in this neighborhood,* has the following features: Surface width of canal, 309 ft.; width over berms, 400 ft.; width at top of bank about 500 ft.; height of bank about 100 ft. The present suspension bridge is substantially at the level of the top of bank, and its towers stand about 50 ft. back of the edge, the span being 600 ft. c. to c. of towers. The clearance height of the bridge floor is only 106½ ft. above maximum lake level (El. + 87) on which the recommended clearance of 175 ft. is based.

The Board made designs for a cantilever bridge and for a plate-rib arch bridge. Both designs provided for a 16-ft. railway width, a 16-ft. highway width and foot-walks, standard loadings being assumed for these various sections. The Board expressed a preference for the arch design; while perhaps more difficult to erect, the arch would offer less exposed surface requiring painting, and would be a stiffer and more satisfactory structure. The cross-section indicates that an arch would require a span of approximately 500 ft. in order to maintain the 175-ft. clearance height over the full width of the canal; its deck would be 75 to 100 ft. above the ground level immediately adjacent to the canal excavation. Any difficulty in securing a good foundation for the abutments would doubtless mean increased span. However, the Board recommended that final selection of design or type of details should not be made until complete comparative estimates have been made.

*Shown by a diagram of the suspension bridge, Eng. News, Dec. 16, 1909, p. 660, Fig. 2.

A Dry-Weather Slide at Culebra.

The geologist's report on landslides at the Culebra Cut of the Panama Canal which we printed a few weeks ago* finds an interesting supplement in a large slide on Feb. 9. This was a dry-weather slide, as the season has been unusually dry for a month or more (less than ¼-in. of rain since Dec. 27, 1910), and the material of the slide was in consequence almost perfectly dry. Also, no local disturbance by blasting, etc., was the active cause, for the only blasting done in the neighborhood of the slide for ten months past was a small amount of mud-capping.

The slide is described in the "Canal Record" of Feb. 15:

> About 10 o'clock on the night of Feb. 9, a section of the east bank of the Canal 1,100 ft. in length, opposite the Y. M. C. A. club-house at Culebra, broke away and settled almost vertically for a distance of about 30 ft., carrying away the berm below it on the 135-ft. level, and displacing laterally this berm and all material west of it up to the pioneer drainage cut, which was almost completely closed. The berm on the 135-ft. level, below the break, varied in width from about 20 ft. at the south end to 100 ft. in the middle of the break, and 50 ft. on the north limit of the break. All loose or broken material lying above this berm had been entirely cleared away by steam shovel only a few days previously.
>
> The entire amount of material in motion aggregates about 550,000 cu. yds., of which about 375,000 cu. yds. lay outside of the theoretical slope of the Canal and about 175,000 cu. yds. within the theoretical limit of the Canal prism. In addition to the material now in motion, as stated above, from 50,000 to 75,000 cu yds. of moving clay will have to be removed from the upper level on the east bank, connecting the shovel cuts thus made with the old French 90-meter level.
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> A steam shovel, a coal train with its locomotive, and two trains of Lidgerwood flats, without locomotives, were caught in the slide, but all have been extricated. All four of the tracks east of the center pioneer cut were carried away, but two of them were restored and ready for operation of trains Friday afternoon. The pioneer cut was filled up, but a pump was installed to the north, and, it is expected, no inconvenience from this source will be experienced.
>
> The 550,000 cu. yds. estimated for the slide of Feb. 9, added to the yardage of the slides that have occurred since July, 1910, do not exceed the total of 6,104,000 cu. yds. allowed for slides in the Central Division in the revised estimate of total excavation made at that time; nor will the added excavation increase the estimate of cost of excavation in the Central Division made in October, 1908.

The description makes it seem likely that this slide belongs to the class "Structural breaks" noted in the geologist's report already mentioned. Crushing of the weakest stratum, at Culebra the lignite or lignitic clay stratum, occurs when the superincumbent weight increases to the stratum's limit of strength. The geologist remarked:

> This type of slide has occurred at various points between Empire and Gold Hill, and in nearly every case the immediate cause appears to be the failure of a lignite bed under the unbalanced pressure due to the excavation. . . . the obvious prevention is in making the slopes sufficiently low.

Related to this matter is the news that on the opposite (west) bank of the Canal, cracks in the ground have appeared under and near the hotel at Culebra, and part of the hotel will be taken down and removed. The increasing depth of the Canal excavation apparently is taxing the crushing resistance of the weaker strata here also.

THE POPULATION OF THE MASSACHUSETTS METropolitan District, according to the U. S. Census of 1910, was 1,378,435, as compared with 858,170 by the U. S. Census of 1890 and 595,482 by the State Census of 1875. The 1910 total includes 670,585 population for Boston alone, 536,206 for 12 other cities and 171,644 for 17 towns (all within ten miles of the State House). The six cities and eight towns contiguous to Boston have a total population of 427,218, thus making, with Boston, a total population of nearly 1,100,000.

*Eng. News, Jan. 5, 1911, p. 21.

The Invention of the Ingersoll Drill and Cameron Pump.

By W. L. SAUNDERS.* M. Am. Soc. M. E.

In a little shop on the corner of Second Ave. and 22d St., New York, both the Ingersoll rock drill and the Cameron steam pump originated. The late Henry C. Sergeant, who probably did more toward the invention and development of the rock drill than any other person, designed the first really successful Ingersoll drill, getting his fundamental ideas of the valve motion from A. S. Cameron, the inventor of the Cameron pump.

The first steam pumps and rock drills were built on steam-engine lines, the valve itself being mechanically connected with the piston. In the first Ingersoll drill, as in the first pump, when the piston reached the end of the stroke it reversed the valve by direct mechanical contact with knuckle joints, rods or other devices, which intervened between the piston and the valve. A. S. Cameron was seeking to perfect a pump which could be used in rough places where exposed parts were liable to wear and injury. He also wanted to make a valve which would open a large port at the end of the stroke the instant that the piston reached a certain point. This was hardly practicable with a mechanically moved valve without excessive shock and wear.

Cameron's invention, therefore, was to place a small tappet or knuckle in each cylinder head of the pump, which should serve as a trigger to trip and open, through contact with the piston, a small port connecting either end of the valve to the exhaust pipe. The valve itself was submerged in live steam, pressure being equal on both sides, hence, when this tripping action took place it reduced the pressure on one end so that the greater pressure on the other caused it to reverse. In order to do this with the minimum shock at the tappet, Cameron later used a tappet to control a plunger piston, which in turn moved the valve itself. This plunger piston had an area on each end which was made greater or less according to the resistance of the valve to the action of sliding on its seat.

Sergeant had a more difficult problem than Cameron, because the speed of a steam pump piston is only about 100 ft. per min., while that of a rock drill piston is four times as great. This high speed made it difficult to use any kind of a tappet trigger, and in order to get the quickest action of the valve, Sergeant sought to use the plunger, or valve moving device of Cameron, as the valve itself.† In doing this he encountered another difficulty, the valve in order to be tight upon its seat would press so hard that the speed of the drill became sluggish, so he ran a bolt through the center of the valve to relieve it of a certain portion of this pressure.

Instead of using a tappet trigger, Sergeant moved his valve by causing the piston of the drill to uncover passages leading to each valve end. Here we have the identical principle, so far as valve movement is concerned, that is embodied in the Cameron pump, namely, an equal pressure on both ends of the valve and the valve moving through a disturbance of that pressure on one end and the other alternately, the action itself being controlled by the strokes of the piston. The Ingersoll "Eclipse" drill and the Cameron pump are at work to-day with valves of this construction.

The community of interests between Cameron and Ingersoll has extended from this inception to the recent coalition of the two companies. The castings for the Ingersoll air compressors were made in the Cameron foundry on East 23d St. for many years, from the very first until the Ingersoll works were moved to Easton, Pa.

A TRAIN FELL FROM A BRIDGE near the American Braden copper mines in Chili, Feb. 24. Reports state that the train, made up of eight cars, fell to the bottom of the ravine, 150 ft. deep, which was spanned by the bridge. In one of the cars were 80 miners, and of these 18 were killed. The other cars of the train were loaded with cement.

*President of the Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

†This same construction is used in Cameron pumps for high pressures (above 150 lbs.).—Ed.

A PREMATURE BLAST of dynamite in a stone quarry near Lincoln, Neb., Feb. 24, killed three men who were engaged in charging the hole.

A FIREWORKS FACTORY EXPLOSION at Silver Lake, N. J., caused the death of three persons. Although the explosion itself involved a comparatively small amount of powder, it caused a fire that completed the destruction of the building, which was a small frame structure.

A MINE FIRE at the Belmont Mine, near Tonopah, Nev., Feb. 23, caused the death of twelve men. A number of others were imprisoned in the mine. The fire started, according to reports, in the timber yard of the mine.

AN EXPLOSION IN THE MUNICIPAL GAS PLANT at Danville, Va., Feb. 22, completely disabled the plant, leaving the city in darkness. The accident occurred shortly after midnight.

A LOCOMOTIVE BOILER exploded Feb. 20 on the Baltimore & Ohio R. R. near Halpine, Md. Three men were killed and a dozen others injured. The locomotive was pulling an extra freight train, at about 15 mi. per hr., when the accident occurred. The accident is ascribed to low water in the boiler.

THE ACCIDENT ON THE BATTLESHIP "DELAWARE," Jan. 17, which was noted in Engineering News of Jan. 19, 1911, has been investigated by a court of inquiry appointed by the Secretary of the Navy. According to the findings of this court, the accident was caused by low water in the boiler. The court held that the water tender, who was one of the nine men killed, was responsible.

A BROKEN RAIL caused the derailment of passenger train No. 10, eastbound, on the Southern Pacific Ry., near Palisade, Nev., Feb. 20. Some twenty passengers were injured.

A PASSENGER TRAIN on the Atchison, Topeka & Santa Fe Ry. was derailed Feb. 20 near Stillwater, Okla. Three passengers were killed and several others badly injured. The accident is ascribed by press reports to the weakening of the roadbed by heavy rains.

TESTS OF STREET CAR FENDERS AND WHEEL-guards are to be undertaken by the Board of Public Improvements of St. Louis, Mo. It is the purpose of the Board to invite entries from any who may be interested. The tests are to be begun about March 27. Mr. Francis J. Cutts is the Engineer-in-Charge.

ACCIDENTS FROM EXPLOSIVES ON RAILWAYS.—"It is a rather curious fact that death produced in this way, by a sudden explosion of material that we have a right to expect to remain unexploded, produces an effect upon our minds entirely incommensurate with the effect produced by the same death in more ordinary ways. There is not as much reason, from the number of deaths concerned, why we should make extraordinary efforts to shut out the cause of 100 deaths from explosion as there would be for our making efforts to shut out a thousand deaths from some other reason, but the fact remains, gentlemen, that one of these explosions on your line will disorganize your entire personnel. I know that, because I have witnessed that disorganization. I have seen the general manager of a railroad pacing the floor on account of such an explosion. I have noted the working of his mind as criticism after criticism from the public press and from his friends and from everybody was received. I have seen the effect upon his superintendents, upon the agent who was involved in the matter, who was up before the bar for investigation. You cannot measure the results of a thing of that kind in dollars and cents. It was days before the railroad on which the explosion occurred was in a normal condition again."—Col. W. B. Dunn in "Transportation of Dangerous Articles," New England Railroad Club, Jan. 10, 1911.

THE ESTIMATED COST OF RAISING THE "MAINE" has increased considerably over the sum suggested by Gen. Bixby in his original report to Congress (Eng. News, Oct. 20, 1910, p. 424). Gen. Bixby's original report contained the following estimate of cost:

> The $300,000 already appropriated will cover the preliminary borings and test-pile driving . . ., the preliminary dredging and removal of loose wreckage . . ., the cost of the steel sheet piling delivered at Havana, the driving of the same, the clay and rock filling of the cylinders, lumber for forms . . ., the banking of the mud inside the cofferdam, the bracing of the wreck, all with a liberal margin for contingencies; and it is quite probable that there will still remain a moderate amount of money available for partial removal of the wreckage. . . . The actual removal of the wreck and restoration of the harbor to its original condition may require a further appropriation from Congress of not exceeding $200,000.

On Feb. 21, Maj. J. B. Cavanaugh, Corps of Engineers, U. S. A., Assistant to the Chief of Engineers, appeared before the Sub-Committee of the House Committee on Appropriations to testify in regard to the advisability of Congress appropriating the additional $350,000 for the work on the "Maine" wreck called for in the current sundry civil bill.

Maj. Cavanaugh stated that under the peculiar weather conditions which surround the work in Havana Harbor it is practically impossible to estimate exactly the amount of money or time it will take to raise the "Maine." In order that the department should not be hampered by lack of funds in case of extraordinary weather conditions, he thought it necessary that an appropriation more than sufficient to care for ordinary conditions should be granted them. He stated that the $350,000 additional, as provided in the bill, might very reasonably be sufficient, but that the department would much prefer $500,000, and, in his opinion, it would not be safe for Congress to fix a limit less than $700,000. This last sum would make the total estimate for the raising of the vessel $1,000,000.

The work which was carried on under the original appropriation is now at a standstill on account of lack of funds. About one-third of the pile cylinders which go to make up the cofferdam have been driven. When the work stopped they were being placed at the rate of about 45 piles a day, and, as there were some 3,200 piles to drive originally, it would take about six weeks of work to complete the pile driving alone. Maj. Cavanaugh stated that the steel sheet piles drop through from 15 to 20 ft. of the soft mud bottom under their own weight, before reaching the fairly hard stratum below. He estimated that it would be about three months before the cofferdam would be ready to be pumped out.

The $350,000 appropriation is based on the following items, which, it will be seen, total to $385,000:

Completing the cofferdam	$50,000
Unwatering dam, bracing ship, etc.	25,000
Removal of wreck and restoring of site to original condition	225,000
Caring for remains, erection of mast, etc.	50,000
Return of plant to the United States, general expenses and contingencies	35,000
	$385,000

The sum of $225,000 for the raising of the vessel proper seemed to one of the members of the Committee to be too high, and he suggested that it would possibly be more desirable to dynamite the wreck once it has been exposed and the remains and fittings removed.

SUIT HAS BEEN BROUGHT against the Akron Water-Works Co. by the city of Akron, Ohio, on account of alleged failure of the company to comply with a portion of the contract of April 16, 1894, between the company and the city. This section of the contract provided that the company must

> maintain good and substantial water-works of sufficient capacity for a full and adequate supply of pure, wholesome water for the use of said city, for fire and all other purposes and for the inhabitants thereof, together with iron or steel mains of ample size to permit of a free flow of water to all parts of the city where said mains may run.

The city brought a similar suit several years ago, gaining a decision in its favor in the lower court but losing on a technicality in the State Supreme Court. The present suit was begun without a jury on Feb. 13, but was soon adjourned to Feb. 27 at the request of the company on account of an offer made by the latter to compromise with the city. It is stated that the company does not deny the inadequacy of the supply conduit from Summit Lake to the pumping station, or the poor quality of the water supplied to the city. The company does claim, however, and this the city denies, that the city and the state are at fault in not protecting the drainage area of the lake from pollution, and maintains that in view of the fact that its franchise has only three more years to run it cannot raise funds for needed improvements. The company has offered to sell out to the city for $850,000, which is about $100,000 less than the valuation put upon the physical property of the company by Mr. Edward W. Bemis, recently Deputy Commissioner of Water-Supply, New York City, and before that Superintendent of Water-Works, Cleveland, Ohio. The city has deferred action on acceptance of this offer until a report on sources of supply can be made by Messrs. Barbour & Bradbury. The city has suggested that the company install a temporary booster pumping station with electric power and a rough or rapid system of filtration with aeration and with hypochlorite treatment. The company has this suggestion under advisement and on securing estimates will decide whether to adopt these temporary expedients or let the suit go on. We are informed that Chester & Fleming, Consulting Engineers, Pittsburg, Pa., are being employed by the water company in connection with the city and that Mr. Bemis, already mentioned, is being employed by the city.

WISCONSIN MUNICIPAL REFERENCE BUREAU.—On July 1, 1909, a municipal reference bureau was established. The purpose of this bureau is to collect data and information on the various departments of municipal activity and government for the purpose of rendering that material available to the cities and citi-

zens of the state. In so far as time and resources permit, the Bureau aims to collect and furnish information on all subjects of municipal organization and administration, public works, public utilities and public-service rates, municipal employment, paving, sewage disposal, water-supplies and water purification, garbage disposal, parks and play-grounds, housing, street cleaning, street sprinkling, dust prevention, smoke abatement, city planning, civic centers, art commissions, care of city trees, schools, charities and corrections, health and sanitation, accounting methods, comparative statistics, commission government, home rule, civic organizations, and all the other subjects of municipal interest, and so far as possible, to collect and maintain a file of charters and ordinances of the principal cities of the United States, and the available municipal material of the principal cities of Europe and the continent. It has correspondents in most of the principal American cities, and in this way is able to furnish information as to what cities have, for instance, a milk ordinance, a wheel tax or other ordinance, how they work, and, if desired, lend a copy of the ordinance. It can tell how boards of public works are organized in various cities, how school boards are constituted, or how street sprinkling or street repairs are paid for. In short, it aims to be a clearing house for municipal experiments and experience.

During the nine months following the establishment of the Bureau, over 900 inquiries from municipal and other officials throughout the state were received and answered, and over 5,000 documents relating to municipal administration were collected.

The results of an investigation of the municipal legislation upon the prevention, care, and cure of tuberculosis in the United States is about ready for publication in bulletin form.

A CONFERENCE ON THE BRITISH HOUSING AND Town Planning Act of 1909 will be held at West Bromwich, England, on July 5 and 6, 1911. The conference is being organized by the Institution of Municipal and County Engineers (11 Victoria St., London, S. W.), which has invited delegates from various municipal corporations throughout the Kingdom to attend. The subjects considered at the conference will fall under two main heads: (1) the act in relation to congested areas and (2) the act in relation to suburban areas. It is expected that a dozen papers "will be contributed by municipal engineers and others best qualified to deal with the subject." Delegates not members of the Institution will pay a fee of 10½s. (about $2.50) for membership in the conference.

Personals.

Mr. David A. Molitor, M. Am. Soc. C. E., Professor of Topographical and Geodetic Surveying at Cornell University, has resigned to devote his time to private practice.

Mr. Arthur L. Gammage, for several years Assistant Chemist for the Connecticut State Board of Health, has taken a position with Mr. Robert Spur Weston, Sanitary Expert, of Boston, Mass.

Mr. Clark R. Mandigo, for the past three years Civil Engineer and Superintendent of Construction with the War Department, has been appointed Assistant City Engineer of Kansas City, Mo.

Mr. E. N. Layfield, M. Am. Soc. C. E., formerly Chief Engineer of the Chicago Terminal Transfer R. R., has been appointed a member of the Grade Separation Commission of Grand Rapids, Mich.

Mr. J. J. Jimenez, formerly Superintendent of Public Works, Department of the Interior, of Porto Rico, has resigned to enter private practice as a consulting and contracting engineer with offices at San Juan, P. R.

Mr. William A. Ehlers, formerly Structural Engineer, Office of the Quartermaster General, War Department, at Washington, D. C., has been appointed Designing Engineer for the Board of Water Supply of the City of Baltimore, Md.

Mr. A. C. Adams, formerly Division Master Mechanic at New Haven, Conn., for the New York, New Haven & Hartford R. R., has been appointed Superintendent of Motive Power of the Spokane, Portland & Seattle Ry. Co., at Portland, Ore.

Mr. W. R. DeWitt, for 20 years U. S. Assistant Engineer engaged in the improvement of the Missouri River, is now associated with Mr. R. O. Shobe, under the firm name of DeWitt & Shobe, Engineering Contractors, at Glasgow, Mo., making a specialty of river improvement work.

Mr. Luman Sherwood, M. Can. Soc. C. E., Principal Assistant Engineer of the Trent Canal, Peterborough, Ont., is announced as the successful competitor for the position of Principal Assistant Engineer, Subdivision A, of the First Division of the Department of Railways and Canals of the Dominion.

Mr. Arthur A. Adams, Superintendent of Streets and Sewers, of Springfield, Mass., has resigned, to take effect April 1. Mr. Adams has held this position for the past 11 years. He will become President of a new firm of contractors to be known as the Birnie, Adams & Ruxton Construction Co., with headquarters at Springfield.

Mr. Thomas C. Clarke, M. Am. Soc. C. E., formerly General Superintendent of the Lackawanna Iron & Steel Co., and for the last three years in charge of the Sheet-Piling Department of the Lackawanna Steel Co., has resigned to accept a position with the Lehigh Coke Co., which is about to build a large plant at South Bethlehem, Pa.

Mr. Calvin Whiteley, Jr., for the past 11 years Chief Engineer of the Virginia Railway & Power Co., of Richmond, Va., has accepted a position with the United Railways & Electric Co., of Baltimore, Md. He will be Acting Chief Engineer during the absence of Mr. John M. Hood, Jr., Assoc. M. Am. Soc. C. E., on a six weeks' trip to Europe.

Dr. Edmund A. Engler, President of the Worcester Polytechnic Institute, has resigned. His resignation will take effect at the end of the present school year. Dr. Engler is a graduate of Washington University, St. Louis, Mo., where he was formerly Professor of Mathematics and Dean of the College of Engineering. He has been President of the Worcester Polytechnic Institute since 1901.

Mr. Charles E. Pugh, First Vice-President of the Pennsylvania R. R., was retired under the company's age limit rules on March 1. He was 70 years af age on Feb. 25 and has been with the Pennsylvania R. R. since Oct. 1, 1859, when he first entered upon railway work. He has been successively, Station Agent, Conductor, Train Dispatcher, Assistant Train Master, General Agent, General Superintendent, General Manager and Vice-President.

Mr. F. L. Fellowes, Assoc. M. Can. Soc. C. E., City Engineer of Westmount, Que., has been appointed Supervising Engineer of Vancouver, B. C., at a salary of $8,000 per annum. Mr. Fellowes, it is reported, expects to take up his new work about the first of May. The appointment is said to be a contract for five years, whereby Mr. Fellowes will have entire control of the Public Works Department, with full power to make and carry out all contracts and to engage all members of his staff.

Obituary.

John Bartholomew, a bridge designer in the office of the State Engineer of New York, at Albany, died at the Albany Hospital in that city on Dec. 31. He was a graduate of Sheffield Scientific School, Yale University, in the class of 1883.

William Harrison Corbett, M. Am. Soc. M. E., President of the Willamette Iron & Steel Works, of Portland, Ore., died from pneumonia at his home in Portland on Feb. 20. He graduated at Stevens Institute of Technology in 1895, and was the son of a prominent iron manufacturer and shipbuilder. He is survived by a widow and two daughters.

Jackson Bolton, Assistant City Engineer of Richmond, Va., committed suicide on Feb. 27, by inhaling illuminating gas. Charges of mismanagement had been preferred against Mr. Bolton by a city council committee and an investigation was about to be held. It is believed by his family and intimate friends that worry caused by these charges and the coming investigation had unbalanced his mind. Mr. Bolton was 61 years of age and one of the oldest in point of service of any of the city employees. City Engineer Bolling is said to have praised his assistant's ability and to have stated that under the clumsy organization of the department, the faithful man was "made a pack-horse and worked to death." Mr. Bolton leaves two daughters and one son, their mother having died several years ago.

Engineering Societies.

COMING MEETINGS.

CANADIAN MINING INSTITUTE.
March 1-3. Annual meeting at Quebec, Que. Secy., H. Mortimer Lamb, Windsor Hotel, Montreal, Que.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.
March 7-9. Annual convention at Toronto, Ont. Secy., Wm. Snaith, 57 Adelaide St., East, Toronto, Ont.

ENGINEERING SOCIETY OF WISCONSIN.
March 8-10. Annual meeting at Madison, Wis. Secy., W. G. Kirchoffer, Vroman Bldg., Madison, Wis.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21-23. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 6-8. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The spring meeting will be held at Pittsburg, Pa., May 30-June 2. The Society has not met in Pittsburg since 1884. Mr. Elmer K. Hiles, 2511 Oliver Bldg., Pittsburg, Pa., is Secretary of the local committee.

AMERICAN HIGHWAY LEAGUE.—The annual meeting was held at St. Louis, Mo., Feb. 23-25. The League is an association of state engineers and highway commissioners. It was founded in May, 1910, at Chicago, as noted in Eng. News, May 19, 1910, p. 598.

NEW ENGLAND WATER WORKS ASSOCIATION.—At the monthly meeting in Boston, March 8, two papers will be presented: "The New England Portion of the Proposed Atlantic Intra-Coastal Waterways," Edward Parrish, Assistant U. S. Engineer, Newport, R. I.; "The Reforestration of Watersheds for Domestic Supplies," F. W. Rane, State Forester of Massachusetts.

LAKE MICHIGAN SANITARY ASSOCIATION.—This association was organized a few years ago to secure concerted action as to the prevention of pollution of Lake Michigan. It is composed of representatives of states and municipalities fronting upon the lake; also engineers, health officers, etc. The fifth annual meeting was held in Chicago on Feb. 18, at which addresses were made by Mr. R. R. McCormick, Dr. W. A. Evans, Mr. Langdon Pearse and others. Mr. W. D. Weiss was elected President and Mr. W. R. Humphrey, Secretary.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.—At the seventh annual convention in Minneapolis, Minn., Feb. 28-March 1, papers were presented as follows: President's address, H. E. Murphy, Manitowoc, Wis.; "Stucco Finishes," Ernest McCullough, Chicago; "Cement Drain Tile Plants," C. M. Powell, Chicago; "Economies in Concrete Construction," Albert A. Pollard, Minneapolis, Minn.; "Marketing Cement Products," Martin T. Roche, St. Paul, Minn.; "Manufacture of Cement Drain Tile," Charles E. Sims, Worthington, Minn.; "Cast Stone Work," C. A. P. Turner, Minneapolis, Minn.; "Reinforced Concrete Construction in Minneapolis," James Houghton, City Building Inspector; "Concrete Highway Bridges," A. E. Lindau, St. Louis, Mo.

AIR BRAKE ASSOCIATION.—The subjects to be considered at the coming convention at Chicago, Ill., May 23-26, and the committees to report thereon have been selected by the executive committee as follows: Air Brake Instruction, Rating, Thos. Clegg (Chairman); Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, John P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves Without Lubricant, Lincoln Leonard; Fiber Stresses in Brake Gear Parts, Geo. O. Hammond; "PC" (air brake) Equipment, W. V. Turner; Steel Pipe versus Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down (Chairman); Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, Prof. A. S. Williamson; Breaking-in-Two of Trains, S. N. Draper and P. J. Langan.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The Society's excursion to Panama begins March 2 with the sailing of the United Fruit Co. steamer "Zacapa" from New York City. A second party is to sail from New Orleans, March 4, both parties being due at Colon, Panama, March 9.

Those who sail from New York March 2 (about 90 persons) are listed below:

Mr. and Mrs. George G. Anderson, Denver, Colo.; Miss R. Adams, Washington, D. C.; Mr. and Mrs. Horace Andrews, Albany, N. Y.; Mr. and Mrs. A. B. Atwater, Detroit, Mich.; Mr. N. F. Brown, Pittsburg, Pa.; Mr. J. E. Bacon, Providence, R. I.; Mr. H. W. Ballou, Providence, R. I.; Mr. and Mrs. Dexter Brackett, Boston, Mass.; Mr. W. F. Ballinger, Philadelphia, Pa.; Mr. G. W. Bramwell, New York, N. Y.; Mr. and Mrs. George Burnham, Philadelphia, Pa.; Mr. E. W. Bush, Saybrook, Conn.; Mr. S. K. Clapp, West Shoken, N. Y.; Mr. and Mrs. E. W. Crellin, Pittsburg, Pa.; Mr. George A. Carpenter, Pawtucket, R. I.; Mr. H. Crosby, New York, N. Y.; Mr. H. J. Deutschbein, Albany, N. Y.; Mr. F. W. Dean, Boston, Mass.; Mr. and Mrs. H. P. Eddy, Boston, Mass.; Mr. Fred Edwards, Troy, N. Y.; Mr. and Mrs. E. H. Foster, New York, N. Y.; Mr. R. W. Fernald, Boston, Mass.; Mr. Henry Floy, New York, N. Y.; Mr. S. M. Green, Springfield, Mass.; Mr. T. T. Harwood, Boston, Mass.; Mr. and Mrs. J. L. Harper, Niagara Falls, N. Y.; Mr. W. K. Hatt, Lafayette, Ind.; Mr. and Mrs. E. Y. Hutchinson, Pittsburg, Pa.; Mr. E. H. Hopson, New Paltz, N. Y.; Mr. J. P. Hogan, High Falls, N. Y.; Mr. D. W. Howes, New Paltz, N. Y.; Mr. and Mrs. George B. Harris, Newark, N. J.; Mr. and Mrs. George T. Horton, Chicago, Ill.; Mrs. C. W. Hunt, New York, N. Y.; Miss Alice R. Hunt, New York, N. Y.; Mr. H. A. Ingwerson, New York, N. Y.; Mr. and Mrs. Chas M. Jarvis, New Britain, Conn.; Mr. Wm. B. Landreth, Schenectady, N. Y.; Mr. F. R. Lanagan, Albany, N. Y.; Mrs. M. A. Lanagan, Albany, N. Y.; Mr. G. W. Lathrop, Providence, R. I.; Mr. W. W. Lewis, Hyde Park, Mass.; Mr. A. V. Lucas, Mt. Vernon, N. Y.; Mr. Chas. R. Main, Boston, Mass.; Mr. Chas T. Main, Boston, Mass.; Mr. and Mrs. R. P. Miller, New York, N. Y.; Mr. W. M. Marple, Scranton, Pa.; Mr. E. H. McHenry, New Haven, Conn.; Mr. F. P. McKibben, South Bethlehem, Pa.; Mr. W. E. Mott, Pittsburg, Pa.; Mr. F. L. McEwan, Albany, N. Y.; Mr. Chas. A. Mead, Upper Montclair, N. J.; Mr. J. A. Norcross, New Haven, Conn.; Col. D. C. Poole, Detroit, Mich.; Mr. J. H. Poole, Detroit, Mich.; Mr. R. S. Parsons, Nutley, N. J.; Mr. F. H. Page, Springfield, Mass.; Mr. and Mrs. J. W. Rollins, Boston, Mass.; Mr. R. V. Rose, Niagara Falls, N. Y.; Mr. C. C. Rose, Scranton, Pa.; Mr. and Mrs. J. W. Rickey, Massena, N. Y.; Mr. C. J. Rannells, Little Hocking, Ohio; Mr. G. W. Rice, Lakeview, Ore.; Mr. R. S. Suydam, Pittsburg, Pa.; Mr. Chas. Stepath, Olive Bridge, N. Y.; Mr. and Mrs. W. J. Sherman, Toledo, Ohio; Mr. F. N. Sanders, Albany, N. Y.; Mr. J. F. Skinner, Rochester, N. Y.; Mr. and Mrs. A. E. Turner, Philadelphia, Pa.; Mr. C. E. Turner, Rochester, N. Y.; Mr. and Mrs. William H. Wiley, Washington, D. C.; Mr. W. O. Wellington, Cambridge, Mass.